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Summaries of NPS Research

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1997

# Summary of Research 1997, Department of Electrical and Computer Engineering

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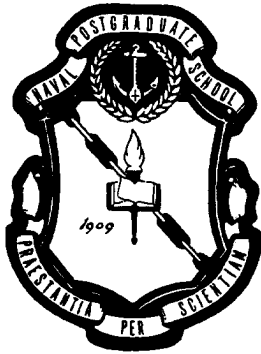


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# ***SUMMARY OF RESEARCH 1997***

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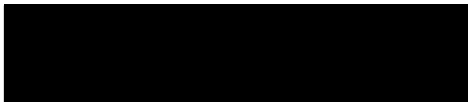
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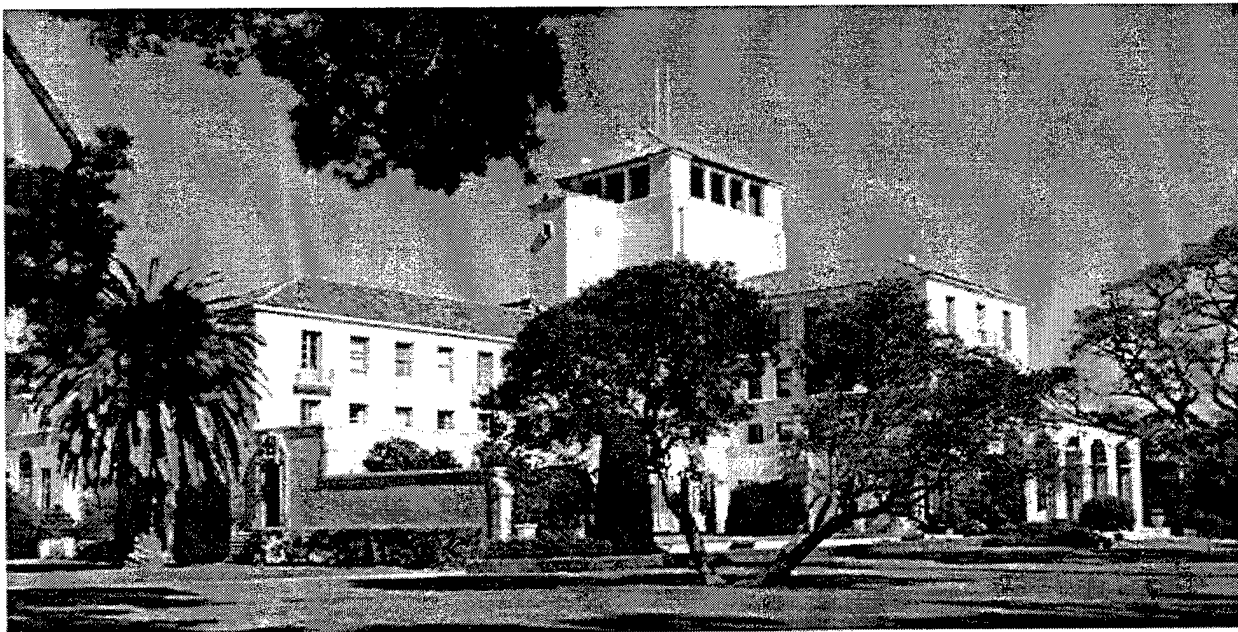
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**DEPARTMENT OF  
ELECTRICAL AND COMPUTER  
ENGINEERING**

**Herschel H. Loomis, Jr.  
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## THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to increase the combat effectiveness of U.S. and Allied armed forces and enhance the security of the USA through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense-related challenges



## CONTENTS

Preface .....	7
Introduction .....	9
Faculty Listing .....	11
Department Summary .....	13
Project Summaries .....	19
A High Data Rate COFDM Mode for UHF Line-of-Sight Communications in a Maritime Environment .....	47
Advanced Phased Array Antenna Technologies .....	38
An Integrated INS/GPSs Shallow-Water Autonomous Underwater Vehicle Navigation System .....	62
Asynchronous Transfer Mode (ATM) Compressed Video Bitstream Modeling and Analysis for Information Warfare .....	42
Beartrap Post-Mission Analysis System .....	53
Chaotic Synchronization for Secure Communication .....	61
CISE Research Instrumentation: Experimental Study of Multiple Mobile Manipulators .....	59
Computer Modeling Techniques for Array Antennas on Complex Structures .....	34
Controller Design, Analysis, and Prototype for Future Navy Surface Ships .....	21
Coordination of Mobile Manipulators .....	58
Data Fusion Algorithms for Vessel Traffic System .....	54
Defensive Asynchronous Transfer Mode (ATM) Modeling and Analysis for Information Warfare .....	43
Development of Mosaic Infrared Modeling System and UWB High Power Microwave Jammer ....	40
DD963 Antenna Data Analysis .....	35
Dynamic Logic Circuits for Complementary Gallium Fabrication Processes .....	28
EA6-B Antenna Design and Evaluation Support.....	37
Economic Evaluation of Voice Recognition for the Clinician's Desktop at the Naval Hospital Roosevelt Roads (NHRR) .....	27
Electromagnetic Characterization of Metallic Platforms Via Eigen-Function Analysis .....	37
Electromagnetic (EM) Scattering from a Tubular Cylinder of Anisotropic Surface Impedances .....	39
Electromagnetic (EM) Signature Source Measurement Using Spatial Spectral Domain Processing .....	47
Enhancements for the Radio Frequency Mission Planner (RFMP).....	20
Evaluations and Extensions of the Probabilistic Multi-Hypothesis Tracking Algorithm to Cluttered Environments .....	32
Experimental Investigation of a High-Speed High-Resolution Direction Finding Array .....	49
Feature-Based Localization and Navigation of Autonomous Mobile Robots .....	60
Field Station Research and Support .....	21
High Performance, Radiation Hardened Integrated Circuit (IC) Technologies .....	57
Improvement in Anti-Ship Cruise Missile (ACSM) Threat Simulator Modeling and Simulation Technology .....	51
Impulse Antenna Modeling .....	48
Information Operations Research Support .....	41
Internet Working Analysis for Counternarcotics Information Operations .....	43
Interactions and Dynamics of Power Electronic Building Block Network Controllers .....	25
LORAN-C: CALOC Time Difference Error Control .....	55
Low Altitude Infrared (IR) Propagation Above Ocean.....	40
Low Cost Finline Filter Construction Method .....	36

Mathematical Modeling of Dolphin Biosonar .....	64
Militarization of Commercial Low Earth Orbit Satellite Systems (LEOS) .....	30
Missile Closure Simulation and Analysis to Support Testing Missile Approach Warning Systems ..	31
Modeling and Simulation of Asynchronous Transfer Mode (ATM) Transport Mechanisms in Large-Scale Networks for Projection of Information Operations .....	44
Multi-Target/Multi-Sensor Fusion Processing Techniques .....	53
Multiple-Valued Computer Logic Circuits .....	23
OPNET Simulation of a Macro-Cell Wireless Network .....	55
Optical Sampling of Microwave Signals .....	50
Organizational Collaboration in a Globally Networked Environment .....	44
Power Electronic Building Block (PEBB) Network Simulation Testbed Validation and the Development of a PEBB Universal Control Library .....	24
Predistortion Techniques for High Power Amplifiers .....	54
Processing of Second Order Statistics Via Wavelet Transforms .....	31
Project Gusty Oriole, Computer Algorithms and Architectures for Space Applications .....	41
Propagation Prediction Techniques Over Rough Ocean and Uneven Terrain .....	33
Radar Terrain Masking Algorithm Evaluation of Tamps, AFMSS, and IMOM .....	41
Radiation Hardening of Space-Based Electronic Devices and Solar Cells .....	45
Radiation Tolerant Bulk CMOS Digital Integrated Circuits .....	28
Radio Frequency (RF) Mesh Networking and Power Management .....	39
Read Prediction Cache Memories for Embedded Microprocessor Systems .....	29
Redundant Number Systems .....	24
Research on a Semi-Autonomous Ground and Aerial Vehicle System for Mine/Unexploded Ordnance (UXO) Detection and Clearing .....	62
SEU Immune Low Temperature Grown GaAs Integrated Circuits .....	56
Signal-to-Noise Enhancement Program (SNEP) Research and Support .....	19
Signal Denoising Using Wavelet Thresholding Techniques .....	26
Support of the Near Shore Tactical Reconnaissance (NSTR) Program .....	63
Surveillance System Studies .....	34
System Modeling and Analysis Center Support for Antenna Performance Evaluation .....	20
The Development of Auxiliary Resonant Commutated Pole (ARCP) Boost Rectifier Controls, and the Construction and Validation of a Soft-Switched DC-to-DC Converter .....	22
Theater Ballistic Missile Defense-Multi-Sensor Fusion, Tracking, and Targeting Techniques .....	33
Time-Domain Simulation of Receiving Systems Using MATLAB/SIMULINK Communications Toolbox .....	38
Ultra-Wideband Impulse Antenna Design .....	48
Uninterruptable Power Supply Design for the AN/MRC 142-Communication System .....	46
Wireless Damage Control Computer Network .....	61
Publications and Presentations .....	65
Thesis Abstracts .....	77
Initial Distribution List .....	113



## PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the School's eleven academic departments, four interdisciplinary groups, and the School of Aviation Safety. This volume contains research summaries for the projects undertaken by faculty in the Department of Electrical and Computer Engineering during 1997. Also included is an overview of the department, faculty listing, a compilation of publications/presentations, and abstracts from theses directed by the department faculty.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the NPS Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2098 (voice) or [research@nps.navy.mil](mailto:research@nps.navy.mil) (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil/~code09/>.

## INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing militarily relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, permitting them to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. This capability is especially important at the present time when technology in general, and information operations in particular, are changing rapidly. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focussed graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at NPS consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- **Reimbursable (Sponsored) Program:** This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with other government laboratories and universities, provides off-campus courses either on-site at the recipient command or by VTC, and provides short courses for technology updates.
- **NPS Institutionally Funded Research Program (NIFR):** The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursable sponsored, (4) to contribute to the recapitalization of major scientific equipment, and (5) to cost-share the support of a strong post-doctoral program.
- **Institute for Joint Warfare Analysis (IJWA) Program:** The IJWA Program provides funding to stimulate innovative research ideas with a strong emphasis on joint, interdisciplinary areas. This funding ensures that joint relevance is a consideration of research faculty.

In 1997, the overall level of research effort at NPS was 151 faculty workyears and exceeded \$32 million. The Department of Electrical and Computer Engineering's effort was 16.31 faculty workyears and exceeded \$3.3 million. The sponsored research program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY97, over 87% percent of the NPS research program was externally supported. In the Department of Electrical and Computer Engineering 88% was externally supported.

The department's research sponsorship in FY97 is provided in Figure 1.

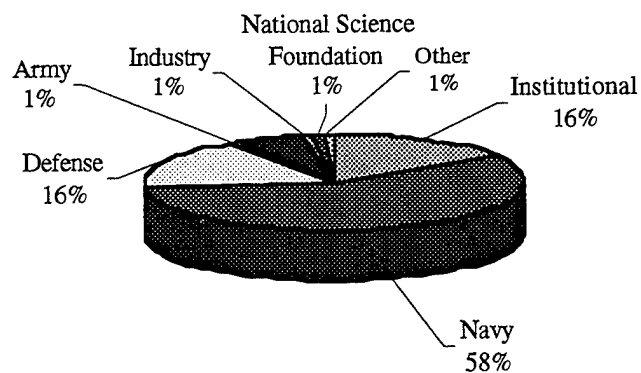


Figure 1. FY97 Sponsor Profile of the Department of Electrical and Computer Engineering

These are both challenging and exciting times at NPS and the research program exists to help ensure that we remain unique in our ability to provide graduate education for the warfighter.

DAVID W. NETZER  
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January 1999

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## DEPARTMENT SUMMARY

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The research program of the Department of Electrical and Computer Engineering (ECE) is very broad, reflecting the variety of skills and interests of the faculty in providing technical advances and solutions to important problems for the Navy and the Department of Defense. DoD research in ECE is strongly coupled to instruction, both in bringing the most recent advances into the classroom and in providing highly relevant and unique thesis topics for officer students to investigate with faculty guidance.

Research in the Department of Electrical and Computer Engineering is supported by an internally funded research program called the Direct Funded Research (DFR) Program, and an externally funded research program called the Reimbursable Research (RR) program. The DFR program includes a Research Initiation Program (RIP) for new faculty and also provides funding for new initiatives, meritorious projects, cost sharing, and a postdoctoral program. The Reimbursable Research Program includes those projects which are externally supported by a wide range of government agencies, and by private industry through Cooperative Research and Development Agreements (CRADAs).

In FY 1997, ECE Department reimbursable research totaled \$3.05M. A total of 16.3 faculty research work years were executed, representing 46% of the Department faculty labor. The Reimbursable Program supported 12.6 faculty work years, or 77% of the total research effort. The department's research work led to 18 journal papers, 61 conference papers, 1 book, 1 book chapter, 23 technical reports, and 1 patent. These publications are listed following the Research Project Summaries.

Research projects in the department can be grouped into the following specialty areas: Communications; Computer Engineering; Electromagnetics; Power Electronics, Electric Machines and Distribution; Infra-red and Electro-optics; Radar, Surveillance, and Information Warfare; Signal Processing/Underwater Acoustics; Guidance, Navigation, and Control; Microelectronics; and Signals Intelligence/Space Systems. Following this introduction is a listing of 1997 research project titles and principal investigators, by specialty area. Although some projects span more than one area, they are listed in only one.

Complete Project Summaries appear following the specialty area listing. These Summaries appear in alphabetical order, according to the principal investigator's surname. Publications, presentations, and these associated with each project are listed. The student thesis involvement in faculty research is evidence of the strong interaction between the department's teaching and research programs.

### Communications

#### RADIO FREQUENCY (RF) MESH NETWORKING AND POWER MANAGEMENT

Chin-Hwa Lee, Professor

#### A HIGH DATA RATE COFDM MODEM FOR UHF LINE-OF-SIGHT COMMUNICATIONS IN A MARITIME ENVIRONMENT

Paul H. Moose, Associate Professor

#### OPNET SIMULATION OF A MACRO-CELL WIRELESS NETWORK

Murali Tummala, Professor

### Computer Engineering

#### MULTIPLE-VALUED COMPUTER LOGIC CIRCUITS

Jon T. Butler, Professor

#### REDUNDANT NUMBER SYSTEMS

Jon T. Butler, Professor

#### READ PREDICTION CACHE MEMORIES FOR EMBEDDED MICROPROCESSOR SYSTEMS

Douglas J. Fouts, Associate Professor

## DEPARTMENT SUMMARY

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PROJECT GUSTY ORIOLE, COMPUTE ALGORITHMS AND ARCHITECTURES FOR SPACE APPLICATIONS  
Herschel H. Loomis, Professor

ORGANIZATIONAL COLLABORATION IN A GLOBALLY NETWORKED ENVIRONMENT  
John McEachen, Assistant Professor

WIRELESS DAMAGE CONTROL COMPUTER NETWORK  
Xiaoping Yun, Associate Professor

### Electromagnetic Systems

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT  
R.W. Adler, Research Associate Professor  
W.R. Vincent, Visiting Research Associate

ENHANCEMENTS FOR THE RADIO FREQUENCY (RF) MISSION PLANNER  
R.W. Adler, Research Associate Professor

SYSTEM MODELING AND ANALYSIS CENTER SUPPORT FOR ANTENNA PERFORMANCE EVALUATION  
R.W. Adler, Research Associate Professor

FIELD STATION RESEARCH AND SUPPORT  
R.W. Adler, Research Associate Professor

PROPAGATION PREDICTION TECHNIQUES OVER ROUGH OCEAN AND UNEVEN TERRAIN  
R. Janaswamy, Associate Professor

COMPUTER MODELING TECHNIQUES FOR ARRAY ANTENNAS ON COMPLEX STRUCTURES  
David C. Jenn, Associate Professor

LOW-COST FINLINE FILTER CONSTRUCTION METHOD  
Jeffrey B. Knorr, Professor

EA6-B ANTENNA DESIGN AND EVALUATION SUPPORT  
Jovan Lebaric, Visiting Associate Professor  
Richard Adler, Research Associate Professor

ELECTROMAGNETIC CHARACTERIZATION OF METALLIC PLATFORMS VIA EIGEN-FUNCTION ANALYSIS  
Jovan Lebaric, Visiting Associate Professor  
Richard Adler, Research Associate Professor

ELECTROMAGNETIC (EM) SCATTERING FROM A TUBULAR CYLINDER OF ANISOTROPIC SURFACE IMPEDANCES  
H.-M. Lee, Associate Professor

ELECTROMAGNETIC (EM) SIGNATURE SOURCE MEASUREMENT USING SPATIAL SPECTRAL DOMAIN PROCESSING  
Michael A. Morgan, Professor

IMPULSE ANTENNA MODELING  
Michael A. Morgan, Professor

## DEPARTMENT SUMMARY

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### ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

Michael A. Morgan, Professor  
R. Clark Robertson, Professor

### EXPERIMENTAL INVESTIGATION OF A HIGH-SPEED HIGH-RESOLUTION DIRECTION FINDING ARRAY

Phillip E. Pace, Associate Professor  
David C. Jenn, Associate Professor

### Power Systems

#### CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS

Robert W. Ashton, Assistant Professor

#### THE DEVELOPMENT OF AUXILIARY RESONANT COMMUTATED POLE (ARCP) BOOST RECTIFIER CONTROLS, AND THE CONSTRUCTION AND VALIDATION OF A SOFT-SWITCHED DC-TO-DC CONVERTER

Robert W. Ashton, Assistant Professor

#### POWER ELECTRONIC BUILDING BLOCK (PEBB) NETWORK SIMULATION TESTBED VALIDATION AND THE DEVELOPMENT OF A PEBB UNIVERSAL LIBRARY

John G. Ciezki, Assistant Professor

#### INTERACTIONS AND DYNAMICS OF POWER ELECTRONIC BUILDING BLOCK NETWORK CONTROLLERS

John G. Ciezki, Assistant Professor

### Signal Processing/Underwater Acoustics

#### SIGNAL DENOISING USING WAVELET THRESHOLDING TECHNIQUES

Monique P. Fargues, Associate Professor

#### ECONOMIC EVALUATION OF VOICE RECOGNITION FOR THE CLINICIAN'S DESKTOP AT THE NAVAL HOSPITAL ROOSEVELT ROADS (NHRR)

Monique P. Fargues, Associate Professor

#### PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS

Ralph D. Hippenstiel, Associate Professor

#### SUPPORT OF THE NEAR SHORE TACTICAL RECONNAISSANCE (NSTR) PROGRAM

Lawrence J. Ziomek, Professor

#### MATHEMATICAL MODELING OF DOLPHIN BIOSONAR

Lawrence J. Ziomek, professor

### Microelectronics

#### RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS

Douglas J. Fouts, Associate Professor

#### DYNAMIC LOGIC CIRCUITS FOR COMPLEMENTARY GALLIUM FABRICATION PROCESSES

Douglas J. Fouts, Associate Professor



## **DEPARTMENT SUMMARY**

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### **SEU IMMUNE LOW TEMPERATURE GROWN GaAs INTEGRATED CIRCUITS**

Todd Weatherford, Assistant Professor

Douglas Fouts, Associate Professor

### **HIGH PERFORMANCE, RADIATION HARDENED INTEGRATED CIRCUIT (IC) TECHNOLOGIES**

Todd Weatherford, Assistant Professor

### **Infra-red and Electro-optics**

#### **LOW ALTITUDE INFRARED (IR) PROPAGATION ABOVE OCEAN**

H.-M. Lee, Associate Professor

#### **DEVELOPMENT OF MOSAIC INFRA-RED MODELING SYSTEM AND UWB HIGH POWER MICROWAVE JAMMER**

Fred Levien, Senior Lecturer

R. Clark Robertson, Professor

#### **OPTICAL SAMPLING OF MICROWAVE SIGNALS**

Phillip E. Pace

John Powers, Professor

### **Radar, Surveillance, and Information Warfare**

#### **MISSILE CLOSURE SIMULATION AND ANALYSIS TO SUPPORT TESTING MISSILE APPROACH WARNING SYSTEMS**

Robert G. Hutchins, Associate Professor

#### **EVALUATION AND EXTENTIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING ALGORITHM TO CLUTTERED ENVIRONMENTS**

Robert G. Hutchins, Associate Professor

#### **THEATER BALLISTIC MISSILE DEFENSE-MULTI-SENSOR FUSION, TRACKING AND TARGETING TECHNIQUES**

Robert G. Hutchins, Associate Professor

#### **SURVEILLANCE SYSTEM STUDIES**

Jeffrey B. Knorr, Professor

#### **DD963 ANTENNA DATA ANALYSIS**

Jeffrey B. Knorr, Professor

#### **TIME-DOMAIN SIMULATION OF RECEIVING SYSTEMS USING MATLAB/SIMULINK COMMUNICATIONS TOOLBOX**

Jovan Lebaric, Visiting Associate Professor

#### **ADVANCED PHASED ARRAY ANTENNA TECHNOLOGIES**

Chin-Hwa Lee, Professor

#### **RADAR TERRAIN MASKING ALGORITHM EVALUATION OF TAMPs, AFMSS, AND IMOM**

Fred Levien, Senior Lecturer

## DEPARTMENT SUMMARY

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### INFORMATION OPERATIONS RESEARCH SUPPORT

Gus K. Lott, Assistant Professor

### ASYNCHRONOUS TRANSFER MODE (ATM) COMPRESSED VIDEO BITSTREAM MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor

### DEFENSIVE ASYNCHRONOUS TRANSFER MODE (ATM) MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor

### INTERNET WORKING ANALYSIS FOR COUNTERNARCOTICS INFORMATION OPERATIONS

John McEachen, Assistant Professor

### MODELING AND SIMULATION OF ASYNCHRONOUS TRANSFER MODE (ATM) TRANSPORT MECHANISMS IN LARGE-SCALE NETWORKS FOR PROJECTION OF INFORMATION OPERATIONS

John McEachen, Assistant Professor

### IMPROVEMENT IN ANTI-SHIP CRUISE MISSILE (ACSM) THREAT SIMULATOR MODELING AND SIMULATION TECHNOLOGY

Phillip E. Pace, Associate Professor

### MEASURES OF EFFECTIVENESS — REDUCED RF SIGNATURES VS. EW COUNTERMEASURES

R. Clark Robertson, Professor

### MEASURES OF EFFECTIVENESS — REDUCED IR SIGNATURES VS. IR COUNTERMEASURES

R. Clark Robertson, Professor

### EVALUATION OF MOSAIC AND GTSIMS FOR MODELING AND SIMULATION OF IR TACTICAL SCENARIOS

R. Clark Robertson, Professor

### IR-TALD

R. Clark Robertson, Professor

### MULTI-TARGE/MULTI-SENSOR FUSION PROCESSING TECHNIQUES

Harold Titus, Professor

### BEARTRAP POST-MISSION ANALYSIS SYSTEM

Murali Tummala, Professor

Charles W. Therrien, Professor

### PREDISTORTION TECHNIQUES FOR HIGH POWER AMPLIFIERS

Murali Tummala, Professor

### DATA FUSION ALGORITHMS FOR VESSEL TRAFFIC SYSTEM

Murali Tummala, Professor

### Guidance, Navigation, and Control

### LORAN-C: CALOC TIME DIFFERENCE ERROR CONTROL

Murali Tummala, Professor

## DEPARTMENT SUMMARY

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### COORDINATION OF MOBILE MANIPULATORS

Xiaoping Yun, Associate Professor

### FEATURE-BASED LOCALIZATION AND NAVIGATION OF AUTONOMOUS MOBILE ROBOTS

Xiaoping Yun, Associate Professor

### AN INTEGRATED INS/GPS SHALLOW-WATER AUV NAVIGATION SYSTEM

Xiaoping Yun, Associate Professor

### RESEARCH ON A SEMI-AUTONOMOUS GROUND AND AERIAL VEHICLE SYSTEM FOR MINE/UNEXPLORED ORDNANCE (UXO) DETECTION AND CLEARING

Xiaoping Yun, Associate Professor

### Signals Intelligence/Space Systems

### MILITARIZATION OF COMMERCIAL LOW EARTH ORBIT SATELLITE SYSTEMS (LEOS)

Tri T. Ha, Professor

### Microelectronics

### RADIATION HARDENED SPACE BASED SOLAR CELLS & ELECTRONIC DEVICES

Sherif Michael, Associate Professor

### UNINTERRUPTABLE POWER SUPPLY DESIGN FOR THE AN/MRC 142-COMMUNICATION SYSTEM

Sherif Michael, Associate Professor

### SEU IMMUNE LOW TEMPERATURE GROWN GaAs INTEGRATED CIRCUITS

Todd Weatherford, Assistant Professor

Douglas Fouts, Associate Professor

### HIGH PERFORMANCE, RADIATION HARDENED INTEGRATED CIRCUIT (IC) TECHNOLOGIES

Todd Weatherford, Assistant Professor

## **PROJECT SUMMARIES**

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### **SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT**

**R. W. Adler, Research Associate Professor**

**W.R. Vincent, Visiting Research Associate**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Security Group Command**

**OBJECTIVE:** Continued research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites and Regional SIGINT Operational Sites (RSOCs) worldwide.

**SUMMARY:** Development continued of techniques and methodology for identifying and locating radio noise sources and sources of interference to data processing and computer systems at the Naval Security Group (NSG) sites worldwide. Support was provided to NSG via review of pre-survey planning documentation, mitigation plans, and authoring "Quick-Look" and final site-survey reports. Students and NSG site personnel were trained as part of the NSG support. A two-day HF Technical Review of Factors that Affect Performance of Naval Receiving Sites was organized and held in Washington, DC, in May 1997.

#### **PUBLICATIONS:**

Vincent, W.R. and Adler, R.W., "SNEP Team Quick-Look Report, NSGD, Rota, Spain, CDAA Site," COMMNAVSECGRU N-44, January 1997.

Vincent, W.R. and Adler, R.W., "Signal-to-Noise Enhancement Program Survey, Quick Look Report," NSGA Northwest," COMMNAVSECGRU N-44, June 1997.

Vincent, W.R. and Adler, R.W., "Signal-to-Noise Enhancement Program Survey, Technical Report, NSGA Northwest," COMMNAVSECGRU N-44, July 1997.

Vincent, W.R. and Adler, R.W., "SNEP Team Quick-Look Report, NSGD, Rota, Spain, CDAA Site," COMMNAVSECGRU N-44, July 1997.

Vincent, W.R. and Adler, R.W., "SNEP Team Signal Reception Survey, NSGA Guantanamo Bay, Cuba," COMMNAVSECGRU N-44, September 1997.

Vincent, W.R., Munsch, G.G., Perry, R.M., and Parker, A.A., "EMI Susceptibility of Communication Cables," Technical Memorandum CABLES9710, USAINSCOM, October 1997.

Vincent, W.R., Adler, R.W., and Myers, H.J., "EMI Leakage into the Radio Frequency Distribution System of a Receiving Site," COMMNAVSECGRU N-44, Naval Postgraduate School Technical Report, NPS-EC-97-006, September 1997.

Vincent, W.R. and Munsch, G.G., "Power-Line Noise Mitigation Handbook, 4th Ed.," COMMNAVSECGRU N-44, Ft. Meade, MD, April 1997.

#### **CONFERENCE PRESENTATIONS:**

Adler, R.W., "Myths of Zero and Equi-Potential Grounds," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Adler, R.W., "Motor Controller EMI Mitigation," Workshop on Factors Affecting the Performance of Naval Receiving Sites," Ft. Meade, MD, May 1997.

Adler, R.W., "Fusion Light Testing," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

## PROJECT SUMMARIES

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Vincent, W.R., "EMI Coupling into the RFD of a CDAA," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Vincent, W.R., "Performance Evaluation Technique," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Vincent, W.R., "High Dynamic Range Amplifiers," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

Vincent, W.R., "Equipment Installation Practices," Workshop on Factors Affecting the Performance of Naval Receiving Sites, Ft. Meade, MD, May 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Environmental Quality

**KEYWORDS:** Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

### ENHANCEMENTS FOR THE RADIO FREQUENCY MISSION PLANNER (RFMP)

**R. W. Adler, Research Associate Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Information Warfare Activity**

**OBJECTIVE:** The goal of this ninth year of a continuing project was to conduct numerical analysis and experimental research in support of the Navy's requirement to site VLF through UHF communication antenna systems and support equipment in non-ideal locations. The effort this year was to support the propagation prediction models of the Radio Frequency Mission Planner (RFMP). In particular, the RFMP provides the warfighter an estimate of the probability of successfully receiving radio signals from 20 to 1500 MHz. The propagation models used in RFMP are tropospheric models that have not been validated in the littoral environment that the Navy is committed to. Data collection of real-world signals is required for the validation process. NPS was tasked to provide the sites and a radio noise-quiet instrumentation van and to conduct automated measurements of received signals in a littoral environment.

**SUMMARY:** The efforts involved the preparation of a radio noise quiet instrumentation van and the installation of an automated RF signal collection system in the van. A companion 6-band automated VHF-UHF transmitter system was also installed onboard the U.S. Coast Guard Cutter for two measurement campaigns and onboard the NPS research ship *Point Sur*. Data was collected along the coastal plain and coastal mountain range system from Santa Cruz to below Big Sur, as well as several inland valleys in San Benito, Santa Clara, Santa Cruz, and Monterey counties. Data reduction and summary reports are in preparation.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Environmental Quality

**KEYWORDS:** Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas, Radiowave Propagation

### SYSTEM MODELING AND ANALYSIS CENTER SUPPORT FOR ANTENNA PERFORMANCE EVALUATION

**R. W. Adler, Research Associate Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Information Warfare Activity**

**OBJECTIVE:** The System Modeling and Analysis Center (SMAC) is tasked to provide personnel and modeling tools to support all tri-service communication systems performance predictions for the warfighter. NPS is supporting this require-

## PROJECT SUMMARIES

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ment by providing user-friendly numerical modeling tools. The first deliverable in 1997, was a Windows graphical I/O interface for the NEC2-MOM antenna code. The completion of the task will include an upgrade of the NEC-2 code (NEC-Win PRO) called GNEC4, based on a customized version of the current NEC-4 code.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Environmental Quality

**KEYWORDS:** Electromagnetic Environmental Effects, Antennas

### FIELD STATION RESEARCH AND SUPPORT

R. W. Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Army Information Security Command

**OBJECTIVE:** Continued research and development in techniques to improve the signal-to-noise ratio at Army Regional SIGINT Operational Sites and receiving sites worldwide.

**SUMMARY:** An electromagnetic interference (EMI) survey was conducted at Ft. Gordon, GA. The performance of receiving signals-of-interest evaluated and the EMI sources observed were documented.

### PUBLICATION:

Vincent, W.R. and Adler, R. W., "EMI Survey at RSOC, Ft. Gordon, GA," USA INSCOM Technical Report, January 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Environmental Quality

**KEYWORDS:** Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

### CONTROLLER DESIGN, ANALYSIS, AND PROTOTYPE FOR

#### FUTURE NAVY SURFACE SHIPS

Robert W. Ashton, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Annapolis Detachment and Naval Postgraduate School

**OBJECTIVE:** Four 100kW buck choppers are currently part of small-scale dc zonal electric distribution system at the Naval Surface Warfare Center (NSWC). The object of this research is to replace the existing first generation buck chopper analog/digital controllers with in-house designed digital signal processing controllers. These new controllers are to be built, programmed, and tested on prototype converters at the Naval Postgraduate School prior to delivery.

**SUMMARY:** During FY97 the programmable universal controller (PUC) was developed and implemented as specified in the "objective" above. The PUC, designed by NSWC personnel, was adopted by this investigator as the second-generation controller. The PUC is TMS320 based with ten available 200kHz A/D converters for acquiring sensor information. The PUC uses a computer for interfacing, and many PUCs may be daisy-chained via fiber optic cable. Electrical isolation is accomplished by the use of fiber optic cable to the power section transistor driver board, the computer interface board, and all follow-on PUCs. Each PUC can control two converters simultaneously. This required the building of three PUCs, two for NSWC and one for the NPS testbed. Documentation of the PUC had to be generated, since little was available from NSWC due to personnel changes.

Two prototype 9kW buck choppers that interface with the PUC were designed, built, and tested. These converters are closely matched so that future paralleling requirements could be implemented. After a PUC was built and tested, assembler code for the TMS320 was developed to run the choppers. The original multi-loop algorithm used in the first generation

## PROJECT SUMMARIES

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controller was coded and burned into the EPROMs. The NPS testbed which includes one PC, one PUC and two 9kW buck choppers was completed. After debugging, the converters were successfully operated at their full-power ratings.

At this point an interface card for the 100kW units at NSWC was designed, cut, populated, and tested at NPS. This card is required for local control, several protection features and the special Power Paragon IGBT driver boards. All necessary components for the new controllers were shipped to Annapolis for integration with the power sections. Currently, the converters are in operation with the new controllers.

This project is expected to continue as additional hardware is added to the distribution system. In the future, a new algorithm for paralleling the units without droop will need to be developed.

### CONFERENCE PRESENTATIONS:

Ashton, R.W. and Ciezki, J.G., "The Formulation and Implementation of an Analog/Digital Control System for a 100kW DC-to-DC Buck Chopper," to be presented at the International Symposium on Circuits and Systems (ISCAS 98), Monterey, CA, June 1998.

Ashton, R.W., Ciezki, J.G., and Badorf, M.G., "The Synthesis and Hardware Validation of DC-to-DC Converter Feedback Controls," to be presented at the Power Electronics Specialists Conference (PESC 98), Tokyo, Japan, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Design of Stabilizing Controls for Shipboard DC-to-DC Buck Choppers Using Feedback Linearization Techniques," to be presented at the Power Electronics Specialists Conference (PESC 98), Tokyo, Japan, June 1998.

### THESES DIRECTED:

Allen, Kirk D., "Practical Implementation of a DC-to-DC Buck Chopper in a Shipboard DC Power Distribution Network," Master's Thesis, Naval Postgraduate School, March 1997.

Badorf, Michael G., "Power Electronic Building Block Testbed Stability Criteria and Hardware Validation Studies," Master's Thesis, Naval Postgraduate School, June 1997.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Other (Energy Conversion)

**KEYWORDS:** Power Electronic Building Blocks, Power System, DC Distribution, Zonal Architecture, Stability, Simulator

### THE DEVELOPMENT OF AUXILIARY RESONANT COMMUTATED POLE (ARCP) BOOST RECTIFIER CONTROLS, AND THE CONSTRUCTION AND VALIDATION OF A SOFT-SWITCHED DC-TO-DC CONVERTER

Robert W. Ashton, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Annapolis Detachment

**OBJECTIVE:** The objective is to deliver an ARCP Boost Rectifier Control algorithm suitable for implementation into the Power Electronic Building Block (PEBB) Universal Control Law Library. Additionally, a soft-switching high-frequency buck converter that is suitable for integration into the PEBB Network Simulation Testbed.

**SUMMARY:** The ARCP Boost rectifier is a core element of the full-scale Power Electronic Building Block (PEBB) demonstration system while the soft-switched DC-to-DC converter is an efficient alternative to a conventional hard-switched topology. The investigator proposes to analyze and design through simulation the appropriate controls for an ARCP boost rectifier. In addition, it is proposed to design and construct a soft-switching high-frequency DC-to-DC converter for application in the PEBB network simulation testbed. Following a review of the device topology and desired operating character-

## PROJECT SUMMARIES

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istics, an appropriate simulation will be implemented and validated against existing hardware. The investigator will then use the simulation to develop suitable controls to ensure that boost operation is achieved and circulating currents are controlled or eliminated. The resultant control algorithm will be made available in a form that will be serial transferable to the PEBB Universal Controller. A hardware demonstration of the proposed control law will be implemented utilizing the fourth ARCP inverter, provided by Pennsylvania State University, and a PEBB Universal Controller - rev 0.

During FY97, extensive models were coded in ACSL. The results were inconclusive. The investigator is still working with the sponsor to further evaluate the system.

The soft-switched DC-to-DC converter proposed work includes a comprehensive literature search of efficient soft-switched resonant converter topologies. The investigator will simulate the attractive topologies and develop appropriate closed-loop controls. One of the topologies will then be selected for prototyping. A prototype of the chosen topology will be implemented at power/frequency levels available in the NPS power systems laboratory. A set of validation studies will be conducted to assess the performance of the unit subjected to both source and load transients. The hardware will then be interconnected into the PEBB Network Simulator to serve as a third DC source deriving power from the phase-controlled rectifier. As the network simulator design can only accommodate two source DC-to-DC converters, the additional converter must be wired with a manual "knife" switch as a hard "OR" selection.

During FY97 a number of resonant converters were investigated. Further, all the materials were purchased for the construction of any one of the investigated designs. The sponsor has not indicated the topology choice at this time.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Other (Energy Conversion)

**KEYWORDS:** Power Electronic Building Blocks, Power System, DC Distribution, Zonal Architecture, Stability, Simulator

### MULTIPLE-VALUED COMPUTER LOGIC CIRCUITS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

**OBJECTIVE:** To analyze the irredundant sum-of-products approach to the design of digital circuits for determining efficient and compact computer designs.

**SUMMARY:** A commonly used approach to the design of digital logic circuits is to produce a sum-of-products expression for a given target function. Such circuits have the property that delay time is low and thus, computation speed is high. Ideally, one wants a sum-of-products expression with as few products as possible, since this produces a compact circuit. However, a class of functions has been discovered for which a recently proposed reduction algorithm produces the worst possible sum-of-products expression. This is quite unsuspected, and suggests that more is needed to understand how poorly such an algorithm can do. The goal of this project is to understand the fundamental properties of sum-of-products circuit design.

#### PUBLICATIONS:

Butler, J.T. and Sasao, T., "On the Properties of Multiple-Valued Functions that are Symmetric in Both Variable Values and Labels," Naval Postgraduate School Technical Report, NPS-EC-97-015, May 1998.

Butler, J.T. and Sasao, T., "On the Properties of Multiple-Valued Functions that are Symmetric in Both Variable Values and Labels," *Proceedings of the 28th International Symposium on Multiple-Valued Logic*, May 1998 (accepted).

Sasao, T. and Butler, J.T., "Comparison of the Worst and Best Sum-of-Products Expressions for Multiple-Valued Functions," *Proceedings of the 27th International Symposium on Multiple-Valued Logic*, pp. 55-60, May 1997.



## PROJECT SUMMARIES

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### CONFERENCE PRESENTATION:

Sasao, T. and Butler, J.T., "Comparison of the Worst and Best Sum-of-Products Expressions for Multiple-Valued Functions," 27th International Symposium on Multiple-Valued Logic, May 1997.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software

**KEYWORDS:** Digital Systems, Compact Circuits, Computer-Aided Design Tools

### REDUNDANT NUMBER SYSTEMS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

**OBJECTIVE:** To analyze the use of redundant number systems in the realization of compact high-speed computation.

**SUMMARY:** In a redundant number system, at least one integer has at least two representations. While redundancy precludes the realization of the maximum number of integers, there are significant advantages. For example, "almost" carryless addition can be achieved, which implies fast computation time. Also, certain applications require representations with certain characteristics; e.g., no more than some upper limit on the number of adjacent 1's. This project is to analyze such number systems to fully realize their benefits.

### PUBLICATIONS:

Butler, J.T. and Sasao, T., "On the Proportion of Digits in Redundant Numeration Systems," *The Fibonacci Quarterly*, pp. 172-180, May 1997.

Butler, J.T. and Sasao, T., "Redundant Multiple-Valued Number Systems," *Proceedings of the Japan Research Group on Multiple-Valued Logic*, Vol. 20, pp. 141-148, July 1997.

### CONFERENCE PRESENTATION:

Butler, J.T. and Sasao, T., "Redundant Multiple-Valued Number Systems," *The Japan Research Group on Multiple-Valued Logic*, July 1997.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Number Systems, High-Speed Numeric Computation

### POWER ELECTRONIC BUILDING BLOCK (PEBB) NETWORK SIMULATION TESTBED VALIDATION AND THE DEVELOPMENT OF A PEBB UNIVERSAL CONTROL LIBRARY

John G. Ciezki, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Carderock Division

**OBJECTIVE:** The proposed work is a continuation of the on-going research effort into the development of a PEBB network simulation testbed. The testbed facilitates the analysis and assimilation of test data concerning the stability of networks containing PEBB-like devices, the interaction of PEBB-like devices and high bandwidth controllers, the investigation of alternative control strategies for PEBB-like devices, and the dynamic performance of devices subjected to system

## PROJECT SUMMARIES

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transients. The simulator has been designed to offer flexibility in system reconfiguration, convenient monitoring, and an expandable architecture to readily integrate new or additional devices.

**SUMMARY:** The investigator completed the development of the simulation testbed and performed preliminary validation studies on various topologies. In addition, a library was developed of control laws for both the DC-to-DC converter and the Auxiliary Resonant Commutated Pole (ARCP) inverter. The simulation testbed work consisted of integrating the final ARCP inverters into the 19 inch rack, verification of the switch lock-out strategy, finalizing the DSP control of each power converter, the validation of a power-up and power-down procedure, the development and implementation of single device start-up, load and load-transient studies, the development and implementation of multiple device start-up, load and load-transient studies, and the modification of cabinet layout to account for any problems with cooling and electro-magnetic interference (EMI).

The Control Law Library work consisted of formulating via simulation appropriate control algorithms for application to both the DC-to-DC converter and the ARCP inverter. The algorithms will, in the future, be converted into C or C++ code that will be serially transferable to the DSP boards (PEBB Universal Controller). A variety of algorithms are available for the ARCP inverter including: space vector (via table lookup), sine-triangle pulse-width modulation, bang-bang pulse-width modulation, battery charger mode, induction machine start-up, and paralleling. Several algorithms are readied for the DC-to-DC converter including: modified state feedback, state feedback with on-line estimator, local exact linearization control, and one-cycle feed-forward control.

### CONFERENCE PRESENTATIONS:

Ciezki, J.G. and Ashton, R.W., "The Resolution of Algebraic Loops in the Simulation of Finite-Inertia Power Systems," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Design of Stabilizing Controls for Shipboard DC-to-DC Buck Choppers Using Feedback Linearization Techniques," to be presented at the Power Electronics Specialists Conference (PESC '98), Tokyo, Japan, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Application of Feedback Linearization Techniques to the Stabilization of DC-to-DC Converters with Constant Power Loads," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Modeling and Simulation, Computing and Software

**KEYWORDS:** Power Electronic Building Block, Power Converters, Controls, Paralleling Algorithm

### INTERACTIONS AND DYNAMICS OF POWER ELECTRONIC BUILDING BLOCK NETWORK CONTROLLERS

John G. Ciezki, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Carderock Division and Naval Postgraduate School

**OBJECTIVE:** The purpose of this research endeavor was to investigate the interaction dynamics of digitally controlled DC-to-DC power converters and Auxiliary Resonant Commutated Pole (ARCP) inverters interconnected in a variety of topologies. In particular, the Navy was interested in quantifying the interaction phenomenon that may occur when several high bandwidth converters are connected as anticipated in the DC Zonal Electrical Distribution System proposed for the twenty-first century surface combatant.

**SUMMARY:** The project consisted of properly developing the controls for the DC-to-DC converters and the ARCP inverters, integrating the units in a variety of series and parallel connections, performing validation studies consisting of variations in loading and transients in the input voltages, and deriving stability conclusions using both validated computer

## PROJECT SUMMARIES

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simulation models and the hardware test results. Interesting tradeoffs were uncovered in terms of designing the control loop for the DC-to-DC converters and optimizing the selection of output capacitance for the units. The paralleling scheme for the DC-to-DC converters utilized the standard droop approach. Future endeavors will investigate the feedback of output current to implement the current share.

### CONFERENCE PRESENTATIONS:

Ashton, R.W. and Ciezki, J.G., "The Design and Fabrication of a Reconfigurable Hardware Testbed for Interaction Analysis of Power Converters in a Reduced-Scale Navy DC Distribution System," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

Ashton, R.W. and Ciezki, J.G., "The Formulation and Implementation of an Analog/Digital Control System for a 100kW DC-to-DC Buck Chopper," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

Ashton, R.W., Ciezki, J.G., and Badorf, M.G., "The Synthesis and Hardware Validation of DC-to-DC Converter Feedback Controls," to be presented at the International Symposium on Circuits and Systems (PESC '98), Tokyo, Japan, June 1998.

Ashton, R.W. and Ciezki, J.G., "The Analysis of Tradeoffs Between Power Section Hardware and Feedback Gains for a DC Distribution System DC-to-DC Converter," to be presented at the International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA, June 1998.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Modeling and Simulation, Computing and Software

**KEYWORDS:** Power Electronic Building Block, High Bandwidth Controllers, Power Electronic Converters

## SIGNAL DENOISING USING WAVELET THRESHOLDING TECHNIQUES

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Undersea Warfare Center-Newport Detachment and Naval Postgraduate School

**OBJECTIVE:** The goal of the study is to investigate the application of the wavelet transform to denoising purposes. The proposed study is divided in two parts. The first part focuses on the type of decomposition and wavelet basis to be used, while the second part investigates specific wavelet thresholding techniques. The study focuses on data provided by the sponsor and results are compared to those obtained using classical Wiener filtering.

**SUMMARY:** This study investigated the application of the wavelet transform and wavelet and cosine packets signal decompositions for the removal of noise from underwater acoustic signals. Several wavelet-based denoising techniques were presented and their performances compared. Results from the comparisons were used to develop a wavelet-based denoising algorithm suitable for a wide variety of signals. Performances of the denoising algorithm were compared to those of a short-time Wiener filter implementation and demonstrated that wavelet-based methods are a viable tool for the denoising of acoustic data.

### PUBLICATIONS:

Fargues, M.P. and Barsanti, R.J., "Wavelet-Based Denoising: Comparisons between Orthogonal and Non-Orthogonal Decompositions," *Proceedings of the 40th Midwest Symposium on Circuits and Systems*, August 1997.

Fargues, M.P., Barsanti, R.J., and Hippenstiel, R., "Wavelet-Based Denoising of Transients," Naval Postgraduate School Technical Report, NPS-EC-97-005, February 1997.

## PROJECT SUMMARIES

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### CONFERENCE PRESENTATION:

Fargues, M.P. and Barsanti, R.J., "Wavelet-Based Denoising: Comparisons between Orthogonal and Non-Orthogonal Decompositions," 40th Midwest Symposium on Circuits and Systems, Sacramento, CA, August 1997.

### OTHER:

Fargues, M.P., "Signal Classification Issues Using Wavelet Decompositions," seminar given at NUWC - Newport, RI, August 1997.

Fargues, M.P., "Signal Denoising and Classification," one-hour briefing presented at NAVSEA, Crystal City, VA, August 1997.

### THESIS DIRECTED:

Bennet, R., Jr., "Classification of Underwater Signals Using a Back-Propagation Neural Network," Master's Thesis, Naval Postgraduate School, June 1997.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Computing and Software

**KEYWORDS:** Signal Classification, Wavelet Transform

### ECONOMIC EVALUATION OF VOICE RECOGNITION FOR THE CLINICIAN'S DESKTOP AT THE NAVAL HOSPITAL ROOSEVELT ROADS (NHRR)

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Student Sponsors: Naval Medical Information Management Center and  
Defense Health Resources Study Center

**OBJECTIVE:** To investigate the status of voice recognition (VR) technology and provide an analysis of the voice recognition pilot project at the Naval Hospital Roosevelt Roads (NHRR). To determine the viability and economic benefits of using a Commercial-Off-The-Shelf (COTS) VR application as a clinician input device for transcribing to clinical encounter (SOAP) notes.

**SUMMARY:** This study investigated the application of voice recognition technology as an input device for electronic medical record (EMR) at NHRR. EMR templates designed to be integrated with the voice recognition software were used for the testing phase. Surveys were designed and distributed both at Navy medical conferences, and at NHRR to evaluate the perception and viability of the pilot project. Findings indicated that the backbone for a successful integration of the technology into the healthcare environment is a strong information system support. In addition, findings showed the following primary healthcare advantages: (1) increased productivity with comparable or better accuracy than can be achieved using existing input methods without negative impact on patient satisfaction and (2) reduction in the need for transcriptionists to transcribe data which can add numerous economical benefits to military healthcare organizations. The primary disadvantages in healthcare are: (1) possible interference from noise, distortion or variability in the user's speech pattern; (2) concerns regarding a patient's privacy violation; and (3) finally, limitations in VR software capabilities.

### PUBLICATION:

Fargues, M.P. and Threet, E., "Economic Evaluation of Voice Recognition for the Clinician's Desktop at the Naval Hospital Roosevelt Roads (NHRR), *Journal of Military Medicine* (submitted November 1997).

## PROJECT SUMMARIES

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### THESIS DIRECTED:

Threet, E., "Economic Evaluation of Voice Recognition for the Clinician's Desktop at the Naval Hospital Roosevelt Roads (NHRR)," Master's Thesis, Naval Postgraduate School, September 1997.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Computing and Software

**KEYWORDS:** COTS, Voice Recognition, EMR

### RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS

**Douglas J. Fouts, Associate Professor**

**Department of Electrical and Computer Engineering**

**Sponsors: National Security Agency and Naval Postgraduate School**

**OBJECTIVE:** To develop circuit designs and mask layout techniques that improve the radiation tolerance of digital integrated circuits fabricated with standard, commercial, bulk CMOS processes.

**SUMMARY:** This research project is investigating circuit designs and mask layout techniques that can be used with standard, commercial, bulk CMOS processes to make digital integrated circuits (ICs) fabricated with these processes tolerant of natural space radiation. Work is concentrating on two areas. First, reducing subthreshold, gate end-around leakage current which is caused by the buildup of radiation-induced charge in the field oxide along the edge of the conducting channel of the transistor. Second, compensating for shifts in threshold voltage that are caused by the buildup of radiation-induced charge in the gate oxide. The first goal of the research has recently been accomplished and work is now proceeding with the second goal. The results of this research will greatly reduce the cost of radiation-tolerant digital integrated circuits for space applications.

### THESES DIRECTED:

Lambley, A.S., "Evaluation of Layout Techniques for Radiation Tolerant Bulk CMOS Integrated Circuits," Master's Thesis, Naval Postgraduate School, September 1997.

Noe, S.S., "Alternative Gate Designs for Improved Radiation Hardness in Bulk CMOS Integrated Circuits," Master's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

**KEYWORDS:** Radiation-Hardened Electronics, Space Electronics

### DYNAMIC LOGIC CIRCUITS FOR COMPLEMENTARY GALLIUM FABRICATION PROCESSES

**Douglas J. Fouts, Associate Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: National Security Agency**

**OBJECTIVE:** To investigate the speed, power consumption, and noise sensitivity of dynamic logic circuits implemented with complementary gallium arsenide fabrication processes.

**SUMMARY:** Logic circuits implemented with gallium arsenide (GaAs) metal field effect transistors (MESFETs) can consume fairly large amounts of power when operated at high frequencies. An alternative is to implement the logic with

## PROJECT SUMMARIES

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complementary hetero isolated gate field effect transistors (CHIGFETs). This yields logic circuits with reduced power consumption but also reduced speed. However, by using the new dynamic logic circuits that have been developed by this research project, in conjunction with a CHIGFET fabrication process, the high speed of GaAs MESFET logic can be maintained while at the same time reducing the power consumption to a level that is below the power consumption for the static logic circuits that are more typically used with CHIGFET fabrications processes.

### PUBLICATIONS:

Fouts, D.J., Shehata, K.A., and Michael, S., "Dynamic Logic Families for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," *Proceedings of the 40<sup>th</sup> IEEE Midwest Symposium on Circuits and Systems*, CD-ROM, Sacramento, CA, 3-6 August 1997.

Shehata, K.A., Fouts, D.J., and Michael, S., "A Dynamic Four-Bit Carry Look-Ahead Adder Circuit for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," *Proceedings of the 40<sup>th</sup> IEEE Midwest Symposium on Circuits and Systems*, CD-ROM, Sacramento, CA, 3-6 August 1997.

### CONFERENCE PRESENTATIONS:

Fouts, D.J., Shehata, K.A., and Michael, S., "Dynamic Logic Families for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," 40<sup>th</sup> IEEE Midwest Symposium on Circuits and Systems, Sacramento, CA, 3-6 August 1997.

Shehata, K.A., Fouts, D.J., and Michael, S., "Dynamic Four-Bit Carry Look-Ahead Adder Circuit for Complementary Gallium Arsenide (CGaAs) Fabrication Processes," 40<sup>th</sup> IEEE Midwest Symposium on Circuits and Systems, Sacramento, CA, 3-6 August 1997.

### PATENT APPLICATION:

Fouts, D.J. and Shehata, K.A., "Two-Phase Dynamic Logic Circuits for Gallium Arsenide Complementary HIGFET Fabrication Processes," November 1997.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

**KEYWORDS:** Dynamic Logic, Gallium Arsenide Logic, Dynamic Gallium Arsenide Logic, High-Speed Low-Power Logic

### READ PREDICTION CACHE MEMORIES FOR EMBEDDED MICROPROCESSOR SYSTEMS

Douglas J. Fouts, Associate Professor  
Department of Electrical and Computer Engineering  
Sponsor: Space and Naval Warfare Systems Command

**OBJECTIVE:** To develop an alternative to second-level cache memories for spacecraft, weapon systems, network controllers, and other embedded high-performance, low-power, microprocessor applications.

**SUMMARY:** Second-level cache memories for high-performance microprocessor systems require large arrays of high-speed, static random access memory (SRAM), which greatly increases the power consumption, weight, physical size, and cooling requirements of the microprocessor integrated circuit (IC) and system. By using address prediction techniques, a significantly smaller cache can provide the same performance with significantly reduced power consumption, weight, physical size, and cooling requirements. Single-chip VLSI implementations of read prediction caches are possible, which can reduce design time and improve system reliability. Inclusion of a read prediction cache memory on the actual CPU chip

## PROJECT SUMMARIES

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is also possible because of the reduced amount of logic required for implementation, compared to a standard second-level cache memory.

### **PUBLICATION:**

Fouts, D.J., Nowicki, G.J., and Aguilar, M.E., "A CMOS Read Prediction Buffer IC for Embedded Microprocessor Systems," *Journal of Microelectronic System Integration*, Vol. 5, No. 3, pp. 129-138, September 1997.

### **PATENT APPLICATION:**

Fouts, D.J., "Predictive Read Cache Memories for Reducing Primary Cache Miss Latency in Embedded Microprocessor Systems," November 1997.

### **OTHER:**

A high-performance, general-purpose, computer architecture simulation program has been written for performing address-trace driven simulations of instruction execution, address patterns, and cache memory and main memory behavior.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Computing and Software, Command, Control and Communications, Electronic Warfare

**KEYWORDS:** Embedded Computing, Portable Computing, High-Speed Networking, High-Performance Microprocessors

## **MILITARIZATION OF COMMERCIAL LOW EARTH ORBIT SATELLITE SYSTEMS (LEOS)**

**Tri T. Ha, Professor**

**Vicente Garcia, National Security Agency Cryptologic Chair**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Postgraduate School**

**OBJECTIVE:** To investigate the use of four commercial low earth orbit satellite systems (LEOS) for disseminating operational intelligence to allies-coalition forces and providing voice and data capability for military applications.

**SUMMARY:** An in-depth study was provided for each of the following four commercial LEOS: Iridium, Teledesic, Odyssey, and Globalstar. Then, a comparison of these systems was performed from the military point of view by using criteria such as anti-jam protection, security, mobility, flexibility, interoperability, coverage, and capacity. It was shown that an architecture consisting of Globalstar and Odyssey had the potential to provide communications support for DoD's less critical needs, which include administration, logistics, and other support functions. Finally, other military applications of these systems were given.

### **THESIS DIRECTED:**

Kakavas, I., "The Applications in Military Communications of Low and Medium Earth Orbit Commercial Satellite Systems," Master's Thesis, Naval Postgraduate School, September 1997.

**DoD KEY TECHNOLOGY AREA:** Other (Communication Networking)

**KEYWORDS:** LEOS, Iridium, Teledesic, Globalstar, Odyssey, ICO

## PROJECT SUMMARIES

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### PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS

Ralph D. Hippenstiel, Associate Professor  
Department of Electrical and Computer Engineering  
Sponsor: Secretary of the Air Force

**OBJECTIVE:** To develop and investigate the properties of a wavelet based approach in detecting and classifying digital modulated signals. A wavelet transform, replacing the traditional Fourier transform in the computation of the time-frequency distribution, is used to obtain a scale-time/delay distribution. Also transformation will be addressed.

**SUMMARY:** This work addresses modulation identification and parameter extraction of digital communication signals. Wavelets are applied to the two-dimensional instantaneous correlation function to extract transition points and to allow modulation identification. Additional parameters are extracted using the transition points obtained in the wavelet processing. Wavelets can be applied along the time or the delay axis. A performance curve versus signal-to-noise ratio (SNR) is provided.

**DoD KEY TECHNOLOGY AREA:** Electronics

**KEYWORDS:** Wavelets, Time Frequency Distributions, Signal Detection/Classification

### MISSILE CLOSURE SIMULATION AND ANALYSIS TO SUPPORT TESTING MISSILE APPROACH WARNING SYSTEMS

Robert G. Hutchins, Associate Professor  
Department of Electrical and Computer Engineering  
Sponsor: Naval Air Warfare Center-Weapons Division

**OBJECTIVE:** The Naval Air Warfare Center-Weapons Division (NAWCWD) is undertaking a study of simulation methodologies to support testing missile approach warning systems (MAWS). They have two programs of interest in this area, the Missile on the Mountain-Ground Mounted Seeker (MOM-GMS) radar enhancement project at the Electronic Combat Range, China Lake, CA, and the Joint Electronic Combat test using SIMulation (JECSIM) Joint Test and Evaluation (JT&E) program. The Naval Postgraduate School (NPS) has been tasked to assist in this effort along two paths: first by acting as the focal point for missile fly-out simulations and studies, and second to assist in the radio frequency (RF) portion of the MAWS study by developing and implementing real-time algorithms to assist a ground-mounted, stationary RF seeker to perceive a more realistic view of incoming targets through the use of simulation enhancements. Comparison of missile fly-out simulations with actual live-fire test data was the dominant research area for FY97.

**SUMMARY:** NAWCWD is involved in a large tri-service effort to develop testing procedures for assessing aircraft response mechanisms to threat surface-to-air missile (SAM) systems. To this end, realistic sensors, sensor simulators, missile fly-out geometries, and end-game intercept geometries for a wide range of sensor types and missile types must be assessed. This research has allowed the Department of Electrical and Computer Engineering to obtain the enhanced surface-to-air missile simulation (ESAMS) code from the Survivability/Vulnerability Information Analysis Center (SURVIAC) at Wright-Patterson Air Force Base. It has been hosted and tested on an SGI Indigo2 computer in the classified computer facility in Root Hall (this code is classified at the SECRET level). Prior work has centered on simulation studies using ESAMS to validate missile end-game behavior for specific threat systems. This past year's research has focused on two areas: an analysis of missile miss distance due to target maneuver and decoy deployment, and the comparison of actual missile flight test data with ESAMS simulated data using the same initial conditions. These results were briefed to the sponsor and others in a classified briefing presented at the Joint Electronic Combat test using SIMulation (JECSIM) Joint Test and Evaluation (JT&E) program review held at NPS, 23 October 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Electronic Warfare, Modeling and Simulation

**KEYWORDS:** Sensors, Integration, Missile Guidance, Real-Time Simulation

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## PROJECT SUMMARIES

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### EVALUATIONS AND EXTENSIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING ALGORITHM TO CLUTTERED ENVIRONMENTS

Robert G. Hutchins, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Undersea Warfare Center-Newport Detachment

**OBJECTIVE:** Dr. Roy Streit and colleagues at the Naval Undersea Warfare Center, Division Newport, have developed a probabilistic multi-hypothesis tracking (PMHT) algorithm that simplifies multi-hypothesis tracking and thus extends the applicability of these techniques to a broader range of problems. Analysis and testing to date have not included three key areas: a comparison with a traditional MHT algorithm, the study of cluttered environments, or the use of attribute data in measurement-to-track association. The purpose of the research effort at NPS is four-fold: (1) to test and validate this new algorithm by comparing it with a traditional MHT algorithm using standardized test scenarios; (2) to study comparative algorithm performance in the presence of clutter; (3) to enhance system performance by revising clutter initiation procedures; and (4) to initiate a study of attribute-augmented measurement-to-track association procedures for potential inclusion in a new algorithm at a later date. The ultimate goal is to develop a workable set of algorithms that is practical and that will achieve reasonable performance in the presence of clutter.

**SUMMARY:** Prior work in this project has produced a set of simulation testbeds and algorithm code. This past year, research has centered on comparison studies with other algorithms and on the use of attribute information to enhance tracking capabilities in clutter. Specifically, addressed was tracking in clutter with varying clutter densities, track initialization problems and procedures, measurement preprocessing, and the use of attribute data for clutter reduction.

#### PUBLICATIONS:

Hutchins, R.G. and Dunham, D.T., "Evaluations of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," *Proceedings of 30<sup>th</sup> Asilomar Signals Systems and Computers*, IEEE Paper, pp 1260-1264, 1997.

Dunham, D.T. and Hutchins, R.G., "Tracking Multi-Hypothesis Targets in Cluttered Environments with a Probabilistic Multi-Hypothesis Tracker," Acquisition Tracking and Pointing XI, M.K. Masden and L.A. Stockum (eds.), *Proceedings of SPIE*, Vol. 3086, pp. 284-295, 1997.

Hutchins, R.G. and Dunham, D.T., "Evaluations and Extensions of the Probabilistic Multi-Hypothesis Tracking Algorithm to Cluttered Environments, Naval Postgraduate School Technical Report, NPS-EC-97-009, December 1996.

#### CONFERENCE PRESENTATIONS:

Dunham, D.T. and Hutchins, R.G., "Tracking Multi-Hypothesis Targets in Cluttered Environments with a Probabilistic Multi-Hypothesis Tracker," SPIE Conference on Guidance and Navigation, Orlando, FL, April 1997.

Hutchins, R.G. and Dunham, D.T., "Evaluations of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," 30<sup>th</sup> Asilomar Signals Systems and Computers, Pacific Grove, CA, November 1996.

#### THESIS DIRECTED:

Dunham, D.T., "Tracking Multiple Targets in Cluttered Environments with the Probabilistic Multi-Hypothesis Tracking Filter," Master's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Modeling and Simulation

**KEYWORDS:** Sensors, Data Association, Target Tracking

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## PROJECT SUMMARIES

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### THEATER BALLISTIC MISSILE DEFENSE-MULTI-SENSOR FUSION, TRACKING, AND TARGETING TECHNIQUES

Robert G. Hutchins, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

**OBJECTIVE:** The ultimate goal is to assess the feasibility of algorithms employing both strategic and theater sensors to detect, track, and engage theater ballistic missiles during boost and/or early ballistic missile flight, destroying the missile over the territory of the aggressor.

**SUMMARY:** The research this past year has focused on initialization and tracking of ballistic missiles during boost phase and through the transition between boost and ballistic flight. Various tracking algorithms have been studied. The effects of initialization on tracker performance to assess the feasibility of performing a hand-off between satellite and earth-based sensors are currently being examined.

#### PUBLICATION:

Hutchins, R.G. and San Jose, A.P., IMM Tracking of a Theater Ballistic Missile during Boost Phase," Oliver Drumond, (ed.), *Proceedings of SPIE Signal and Data Processing of Small Targets*, Vol. 3373, pp. 528-537, 1998.

#### CONFERENCE PRESENTATION:

Hutchins, R.G. and San Jose, A.P., "IMM Tracking of a Theater Ballistic Missile during Boost Phase," SPIE Signal and Data Processing of Small Targets, Orlando, FL, April 1998.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Modeling and Simulation

**KEYWORDS:** Theater Ballistic Missiles, Sensors, Extended Kalman Filters, Data Association, Target Tracking

### PROPAGATION PREDICTION TECHNIQUES OVER ROUGH OCEAN AND UNEVEN TERRAIN

R. Janaswamy, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego and Naval Postgraduate School

**SUMMARY:** The problems of radiowaves propagating over rough ocean surface and in non-standard atmosphere and that of radiowaves propagating over uneven terrain and inhomogeneous atmosphere were solved by the parabolic equation method. Both horizontal and vertical polarizations were considered. FORTRAN codes were developed for both and delivered to sponsor.

**DoD KEY TECHNOLOGY AREA:** Command, Control and Communications

**KEYWORDS:** Radiowave Propagation

## PROJECT SUMMARIES

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### COMPUTER MODELING TECHNIQUES FOR ARRAY ANTENNAS ON COMPLEX STRUCTURES

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force and Naval Postgraduate School

**OBJECTIVE:** The objective of this research is to investigate the suitability of using several existing computational electromagnetics (CEM) codes in modeling antenna problems to predict the antenna's performance when it is in its operational environment, that is, when installed on a platform with other objects near it or in its field of view.

**SUMMARY:** Several off-the-shelf CEM codes have been used to model a wide range of antenna problems. They include simple dipoles and slots as well as microstrip patches and horns. These codes are well suited to the evaluation of antenna gain and pattern characteristics under various operational conditions. The purpose of this research was to demonstrate some of the features of the codes that are of use in the design and analysis of antennas on complex structures. The performance of individual elements and arrays of elements on complex structures has been computed using electromagnetic patch codes. Complex structures are defined as those with curved surfaces, edges, protrusions, and multiple materials.

Many of the codes are derivatives of RCS prediction codes, and have been thoroughly validated. Furthermore, pre- and post-processing tools have been developed to generate geometry models and visualize data. All of the codes examined in this study are available free to government agencies and contractors.

#### PUBLICATIONS:

Jenn, D.C. and Herzog, S., "Computed and Measured Radiation Patterns of Antennas with Aerodynamic Radomes," *Proceedings of the Applied Computational Electromagnetics Symposium*, March 1997.

Jenn, D.C., "Computer Modeling Techniques for Array Antennas on Complex Structures," Naval Postgraduate School Technical Report, NPS-EC-97-016, December 1997.

#### OTHER:

Jenn, D.C., "Computer Modeling Techniques for Array Antennas on Complex Structures," Progress Report, 1 July 1997.

#### THESIS DIRECTED:

Daniil, I.E., "Analysis of Finite Phased Arrays on Shaped Ground Planes," Master's Thesis, Naval Postgraduate School, December 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Modeling and Simulation

**KEYWORDS:** Array Antennas, Computational Electromagnetics

### SURVEILLANCE SYSTEM STUDIES

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Sponsors: Space and Naval Warfare Systems Command and Naval Postgraduate School

**OBJECTIVE:** The objective of this project was to investigate the feasibility of using a computer simulation of a high frequency, shipboard direction finding system as a recalibration decision support system.

**SUMMARY:** Shipboard direction finding (DF) in the high frequency (HF) band is complicated by the fact that the antenna elements in the DF array interact strongly with the ship's superstructure. Thus, a DF technique such as correlation interfer-

## PROJECT SUMMARIES

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ometry direction finding (CIDF), which accounts for the effects of the superstructure must be used. However, CIDF requires a calibration database of DF antenna responses and any changes made to the superstructure after calibration may affect the accuracy of bearing estimates. This poses a problem, as one must know when a topside change will result in the need to recalibrate a ship—a costly and time consuming process.

A computer simulation was developed using operational system software. It was constructed to accept numerical, scale model, or real ship data, and to display correlation and bearing error results using 2D and 3D graphic displays. Numerical models of the DD963 Spruance Class destroyer were developed for two different topside configurations. The models were numerically calibrated and the bearing error caused by changing configuration was determined. Experimental data were used to validate the simulation.

Results were obtained at four frequencies through the HF band. Numerical and experimental DF antenna responses were in good agreement at the lower frequencies. At the higher frequencies, numerical and experimental DF antenna responses were not in good agreement. This was attributed to correctable deficiencies in the numerical ship models. Similarly, numerical and experimental correlation and bearing error results showed good agreement at low frequencies and poor agreement at high frequencies. However, numerical and experimental values of RMS bearing error, which is an integrated performance measure, showed good correspondence at all frequencies.

This work has shown that computer simulation could be used as a basis for developing a ship recalibration decision support system. Areas requiring further development to facilitate this approach include: (1) generation of ship numerical models from CAD files and (2) development of EM code pre/post processors for editing input data files, visualization of input data files, and viewing output data files. A comparison of the performance of available EM codes for this application would also be desirable. The simulation is immediately useful for analysis of real-ship data.

### PUBLICATIONS:

Knorr, J.B., "Numerical and Experimental Responses for the OUTBOARD DF Antennas on the DD963 Spruance Class Destroyer," Naval Postgraduate School Technical Report, NPS-EC-97-008, April 1997.

Knorr, J.B., "Application of Computational Electromagnetics to Shipboard HFDF System Simulation," *Proceedings of the 13<sup>th</sup> Annual Review of Progress in Applied Computational Electromagnetics*, pp. 182-192, Monterey, CA, 17-21 March 1997.

Knorr, J.B., "Shipboard HFDF System Simulation," *Applied Computational Electromagnetics Society Journal*, accepted for publication, March 1998.

### CONFERENCE PRESENTATION:

Knorr, J.B., "Application of Computational Electromagnetics to Shipboard HFDF System Simulation," 13th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA, 17-21 March 1997.

**DoD KEY TECHNOLOGY AREAS:** Battlespace Environments, Command, Control and Communications, Electronic Warfare, Modeling and Simulation, Sensors

**KEYWORDS:** Direction Finding, DF, HFDF, Modeling and Simulation, Computational Electromagnetics, CEM

### DD963 ANTENNA DATA ANALYSIS

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

**OBJECTIVE:** The objective of this project was to transfer NPS developed simulation technology for analysis of DD963 antenna data.

## PROJECT SUMMARIES

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**SUMMARY:** A computer simulation of the DD963 Spruance Class destroyer high frequency direction finding simulation was transferred to the RDT&E Division of SSC-SD. The various data processing, signal processing, and display software programs were provided along sample files and a User's Guide.

**OTHER:**

Knorr, J.B., "OUTBOARD DF System Simulation: User's Guide, Software, and Sample Files," prepared for Code D-8505, RDT&E Division, SSC-SD, San Diego, CA, 14 pp. plus software and sample files on disk.

**DoD KEY TECHNOLOGY AREAS:** Battlespace Environments, Command, Control and Communications, Electronic Warfare, Modeling and Simulation, Sensors

**KEYWORDS:** Direction Finding, DF, HFDF, Modeling and Simulation, Computational Electromagnetics, CEM

### LOW COST FINLINE FILTER CONSTRUCTION METHOD

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

**OBJECTIVE:** The objective of this research was to investigate a low cost approach to the construction of finline bandpass filters for use at microwave and millimeter wave frequencies.

**SUMMARY:** In those applications where low insertion loss is required, waveguide is normally the best choice of medium for filter construction. Finline is an attractive choice for fabrication of the filter elements because printed circuit techniques can be used to produce the filter structure. Often the filter structure is fabricated using a thin piece of beryllium copper which has both stiffness and good conductivity. The printed filter structure is supported in the waveguide, in the E-plane, by bifurcating the waveguide and clamping the filter structure between the two halves of the waveguide. However, this approach to filter construction only partially addresses the issue of low cost since the waveguide halves must be machined.

A new approach to the construction of finline bandpass filters was investigated. Beryllium copper was used to fabricate a filter insert which was bent in a way which permitted it to be inserted directly into a standard waveguide. The response of this filter was measured and initially it was found that poor contact between the insert and the waveguide walls resulted in unacceptably high insertion loss. This problem was solved by using a conductive lubricant. The final result was an extremely simple, low cost filter construction method which resulted in an insertion loss which was only slightly greater than that of the conventional construction method.

**PATENT:**

Knorr, J.B., "Low Cost Finline Filter Construction Method," invention disclosure dated 22 December 1997.

**DoD KEY TECHNOLOGY AREA:** Electronics

**KEYWORDS:** Finline Filter

## PROJECT SUMMARIES

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### **EA6-B ANTENNA DESIGN AND EVALUATION SUPPORT**

**Jovan Lebaric, Visiting Associate Professor**

**Richard Adler, Research Associate Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Surface Warfare Center-Crane Division**

**OBJECTIVE:** To cooperate with the contractor (AEL-Tracor) and Crane NSWC in predicting the performance of the proposed antennas for the EA6-B AN/ALQ-99 Low-Band Transmitter.

**SUMMARY:** AUTOCAD models of proposed antennas, the AN/ALQ-99 pod and the EA6-B aircraft were used as inputs to a Method of Moments program (named MOM-IV and developed at the NPS) to predict the radiation patterns and input impedances over a wide frequency range. The results were presented in the form of two reports, one for vertically polarized antennas and one for horizontally proposed antennas.

**DoD KEY TECHNOLOGY AREA:** Sensors

**KEYWORDS:** Antennas, Modeling and Simulation

### **ELECTROMAGNETIC CHARACTERIZATION OF METALLIC PLATFORMS VIA EIGEN-FUNCTION ANALYSIS**

**Jovan Lebaric, Visiting Associate Professor**

**Richard Adler, Research Associate Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Engineering Logistics Office**

**OBJECTIVE:** To determine the "frequencies of opportunity" (resonances) of complex metallic objects and platforms such as missiles, land vehicles, aircraft, and ships, and the associated current distributions for the purposes of antenna coupling evaluation, improving detection of metallic targets (radar targets as well as unconventional targets such as concealed weapons), maximizing the effectiveness of electromagnetic attack, etc.

**SUMMARY:** Electromagnetic eigen-analysis program named EIGEN that had been developed at NPS by the PIs has been further improved with the NELO funding to predict more accurately the frequencies of electromagnetic resonances (and the associated current distributions and far field patterns) of complex metallic objects, based on the AUTOCAD wire-grid models as input. The work also involved the development of the Graphical User Interface (GUI) and will continue into 1998.

#### **CONFERENCE PRESENTATION:**

Lebaric, J., "Method of Moments Eigen-Analysis," NATO Advanced Study Institute in Applied Computational Electromagnetics, August 1997.

#### **THESIS DIRECTED:**

Lintz, W., "Electromagnetic Resonances of Metallic Bodies," Master's Thesis, Naval Postgraduate School, June 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Modeling and Simulation

**KEYWORDS:** Modeling and Simulation, Electromagnetic Resonance, Eigen-Analysis

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## PROJECT SUMMARIES

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### TIME-DOMAIN SIMULATION OF RECEIVING SYSTEMS USING MATLAB/SIMULINK COMMUNICATIONS TOOLBOX

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

**OBJECTIVE:** To develop a specialized "toolbox" to simulate the process of signal intercept in the time domain.

**SUMMARY:** A custom SIMULINK library has been developed with models of communications and radar signals and corresponding receivers to simulate the processes of signal generation, interference, and reception in the time domain. Baseband equivalence of passband system has been implemented in order to reduce the computational times. Two thesis students have been participating in the research.

**DoD KEY TECHNOLOGY AREAS:** Modeling and Simulation, Command, Control and Communications

**KEYWORDS:** Modeling and Simulation, Communications, MATLAB, SIMULINK

### ADVANCED PHASED ARRAY ANTENNA TECHNOLOGIES

Chin-Hwa Lee, Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Intelligence

**OBJECTIVE:** To access performance and costs of advanced phased array antenna technologies in emerging radar systems.

**SUMMARY:** An analysis program was developed to access the tracking performance of phased array antenna. The study involved investigation of most recent active phased array radar systems in development around the world. The range and tracking performance were examined versus costs that indicate the future trend of the new radar systems.

#### PUBLICATION:

Lee, C.H., "Decentralized Power Management Algorithm for Frequency Reuse," *Proceedings of the IEEE MILCOM Conference*, Monterey, CA, November 1997.

#### THESES DIRECTED:

Nimitbunanan, N., "Video Conferencing Using Packet Radio Technology," Master's Thesis, Naval Postgraduate School, June 1997.

Rodriguez, Alfredo, "Probability of Bit Error in Cochannel Interference and Fading," Master's Thesis, September 1997.

Sari, M., "Designing Fast Golay Encoder/Decoder in Xilinx XACT with Mentor Graphics CAD Interface," Master's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREA:** Sensors

**KEYWORDS:** Radar, Antenna

## PROJECT SUMMARIES

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### RADIO FREQUENCY (RF) MESH NETWORKING AND POWER MANAGEMENT

Chin-Hwa Lee, Professor

Department of Electrical and Computer Engineering

Sponsors: Space and Naval Warfare Systems Center-San Diego

**OBJECTIVE:** Investigate the multiple access technology for Navy UHF high speed links.

**SUMMARY:** The main accomplishment in the frequency reuse project is the development of the simulation program. The simulation program was improved to test out the traffic capacity of a carrier sensed collision avoidance multi-access system. The main purpose of the multi-access system is to increase the total communication capacity of the Navy ship-to-ship and ship-to-shore UHF links. Throughput and link delay were measured and compared to the theoretical results.

**PUBLICATION:**

Lee, C.H., "Decentralized Power Management Algorithm for Frequency Reuse," *Proceedings of the IEEE MILCOM Conference*, Monterey, CA, November 1997.

**THESIS DIRECTED:**

Rodrigues, A., "Probability of Bit Error in Cochannel Interference and Fading," Master's Thesis, Naval Postgraduate School, September 1997.

**DoD KEY TECHNOLOGY AREA:** Command, Control, and Communications

**KEYWORDS:** Command, Control, and Communications, Communication

### ELECTROMAGNETIC (EM) SCATTERING FROM A TUBULAR CYLINDER OF ANISOTROPIC SURFACE IMPEDANCES

H.-M. Lee, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

**OBJECTIVE:** To investigate the effects of impedance coating on the scattering of electromagnetic waves by a body.

**SUMMARY:** The electromagnetic scattering from a zero-thickness, perfectly conducting, circular, tubular cylinder of finite length with different anisotropic coatings on its inside and outside surfaces is investigated. The induced electric and magnetic surface current densities and the far field are obtained. Analytical expressions of the double series expansion coefficients of the kernels of the integral-differential equations of this problem are found and utilized in the computation to assure that extremely accurate numerical results can be obtained. These results will be used as a standard for validating numerical electromagnetic computation codes.

**PUBLICATION:**

Lee, H.-M. and Yu, C.-K., "A Theorem of Anisotropic Absorbers," Naval Postgraduate School Technical Report, NPS-EC-97-004, March 1997.

**DISSERTATION DIRECTED:**

Yu, C.-K., "Electromagnetic Scattering of an Anisotropically Coated Tubular Cylinder," Doctor of Philosophy Dissertation, Naval Postgraduate School, March 1997.



## PROJECT SUMMARIES

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**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Electronics, Electronic Warfare

**KEYWORDS:** Radar Cross Section, Sensors, Low Observables

### LOW ALTITUDE INFRARED (IR) PROPAGATION ABOVE OCEAN

H.-M. Lee, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

**OBJECTIVE:** Examine the fluctuation in the strength of low altitude propagation of infrared beam above ocean surface to determine the effects of temperature profile and ocean waves.

**SUMMARY:** Fluctuation in the received strength of infrared beam transmitted over the ocean surface is investigated. The temperature, wind speed and ocean wave data are used to construct the temperature profile to correlate with the recorded infrared (IR) beam strength information. The results should improve our understanding of the effects of ocean environment on IR sensors.

#### DISSERTATION DIRECTED:

Yeoh, L.-W., "Low Altitude Optical Propagation Over the Ocean, Volume I and II," Doctor of Philosophy Dissertation, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREAS:** Battlespace Environment, Sensors

**KEYWORDS:** Infrared Sensor, Environmental Effects

### DEVELOPMENT OF MOSAIC INFRARED MODELING SYSTEM AND UWB HIGH POWER MICROWAVE JAMMER

Fred Levien, Senior Lecturer

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center-Weapons Division

**OBJECTIVE:** The mosaic infrared modeling and simulation system will be employed in evaluating the survivability of the SH-60B Seahawk helicopter in the new tactical roles envisioned for it. Efforts will continue to establish a closer support relationship between NPS and other EWAT teams to ensure a wider availability of infrared M&S for use in their research. Work will continue on developing tactical tools for delivering UWB expendable jammers to counter military and civilian communication system. Sources will be built and tested configured for both airborne and special forces delivery.

**DoD KEY TECHNOLOGY AREA:** Other (Infrared Countermeasures)

**KEYWORDS:** Infrared, Missiles, Ultrawide Band, Jamming, Expendables

## PROJECT SUMMARIES

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### **RADAR TERRAIN MASKING ALGORITHM EVALUATION OF TAMPS, AFMSS, AND IMOM**

**Fred Levien, Senior Lecturer**

**Department of Electrical and Computer Engineering**

**Sponsor: Operations Test and Evaluation Force**

**OBJECTIVE:** To support the investigation of radar terrain masking (RTM) generation, and presentation characteristics using three DoD mission planning models, TAMPS, AFMSS, and IMOM. Using theoretical and flight test data collected, establish a criteria level which will be used as part of the joint mission planning system (JMPS) scheduled to be online shortly after the turn of the century.

**DoD KEY TECHNOLOGY AREA:** Modeling and Simulation

**KEYWORDS:** Simulation Verification, Validation, Accreditation

### **PROJECT GUSTY ORIOLE, COMPUTER ALGORITHMS AND ARCHITECTURES FOR SPACE APPLICATIONS**

**Herschel H. Loomis, Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Secretary of the Air Force**

**OBJECTIVE:** This project is concerned with the application of computer algorithms to specific military space projects, the development of specialized computer architectures for military space applications and the support of the space operations curriculum.

**DoD KEY TECHNOLOGY AREA:** Sensors

**KEYWORDS:** Military Space, Computer Architectures

### **INFORMATION OPERATIONS RESEARCH SUPPORT**

**Gus K. Lott, Assistant Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Information Warfare Activity**

**OBJECTIVE:** To promote information operations (IO) research among the 30 to 40 cryptologic officers attending NPS. To promote general IO research in all three major areas: protection, exploitation, and attack.

**SUMMARY:** Work continued on supporting two major Naval Information Warfare Activity (NIWA) projects in the area of geopositioning systems and radio frequency mission planning. In geopositioning, work included simulation of cyclostationary processing techniques to NIWA's multi-platform time difference of arrival system. Geopositioning work also included solution improvement by incorporating real-time space weather information and computerized ionospheric tomography. Radio Frequency Mission Planning (RFMP) work included better propagation prediction by using real-time environmental information. Work also included further refinement of the "Lott Plot" techniques for prediction of mission success.

#### **PUBLICATION:**

Lott, G.K., "Navy Requirements for Space Weather Information," *Proceedings of the Space Weather Effects on Propagation of Navigation and Communications Signals*, COMSAT, Bethesda, MD, October 1997.

## PROJECT SUMMARIES

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### CONFERENCE PRESENTATIONS:

Lott, G.K., "Public-Key Cryptography," Annual Atlantic-Fleet Cryptologic Officers Meeting, Norfolk, VA, January 1997.

Lott, G.K., "Tactical Uses of Computerized Ionospheric Tomography," 1<sup>st</sup> International Conference on Computerized Ionospheric Tomography, Applied Research Laboratory, University of Texas at Austin, Austin, Texas, February 1997.

Lott, G.K., "Computer Modeling for Wireless System Planning," National Association of Telecommunications Officials and Administrators (NATOA), Tucson, AZ, September 1997.

Lott, G.K., "Tactical Applications of and Distribution Means for Near-Real-Time Space Weather Information," Space Weather Effects on Propagation of Navigation and Communications Signals, COMSAT, Bethesda, MD, October 1997.

### THESIS DIRECTED:

Streight, D.A., "Application of Cyclostationary Signal Selectivity to the Carry-On Multi-Platform GPS Assisted Time Difference of Arrival System," Engineer's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Electronic Warfare, Other (Signals Intelligence, Information Operations)

**KEYWORDS:** Radio Propagation Modeling, Propagation Model Validation, Computerized Ionospheric Tomography, Time-Difference-of-Arrival, Geopositioning

### ASYNCHRONOUS TRANSFER MODE (ATM) COMPRESSED VIDEO BITSTREAM MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Engineering Logistics Office and Naval Postgraduate School

**OBJECTIVE:** To develop models for efficient processing of compressed video observed over an ATM network. To establish a testbed high-speed network within NPS for testing and evaluation of networked video. It is anticipated that work associated with this effort will be transitioned to the project entitled "Defensive ATM Modeling and Analysis for Information Warfare."

**SUMMARY:** The initial components for an ATM high-speed video network were identified, procured, installed, and configured resulting in a significant upgrade to the Department of Electrical and Computer Engineering's networking laboratory facilities. The development of this lab has already benefited students in the EC3850 class. A commitment was obtained from the Naval Engineering Logistics Office (NELO) to cover the remaining shortfall in initial proposed DFR funding. The initial taxonomy and algorithms to be used in the analysis of video bitstreams has been developed. Additionally, software from interested DoD agencies has been acquired and installed. Ongoing work involves coding and evaluation of the analysis algorithms.

**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Modeling and Simulation, Computing and Software

**KEYWORDS:** Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

## PROJECT SUMMARIES

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### DEFENSIVE ASYNCHRONOUS TRANSFER MODE (ATM) MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor  
Department of Electrical and Computer Engineering  
Sponsor: Naval Engineering Logistics Office

**OBJECTIVE:** To develop models and simulations of standards-based digital communications networks using MILs' OPNET network modeling software environment. To determine infrastructure constraints and vulnerabilities based on simulated results. This work is part of a continuing project with the Naval Engineering Logistics Office (NELO).

**SUMMARY:** Two subprojects have been identified in relation to this project: (1) IT-21 standards-based modeling for susceptibility analysis and (2) electronic content modeling, recognition, and identification from ATM bitstreams. All of the work on this project has been performed on a Sun Ultra workstation procured, installed, and configured in restricted spaces. With respect to the first topic, a baseline simulation model has been developed for a projected IT-21 standards-based network. Additionally, two initial attack simulations have been developed and are under evaluation. Under the second subproject, several protocol analysis packages were evaluated and modified to all bitstream evaluation. A consolidated suite of tools was formed and installed on the workstation and evaluation is ongoing on synthetic data.

#### PUBLICATION:

McEachen, J.E., "Defensive ATM Modeling and Analysis for Information Warfare," Naval Postgraduate School Technical Report, NPS-EC-98-006, February 1998.

#### OTHER

Data Communications Analysis Tools Suite (DCATS). A collection of software protocol analysis tools consolidated at the request of a sponsor (NELO) and forwarded via DCS, 19 December 1997. These software tools allow near-real-time analysis of a large variety of data communication protocols in a user-friendly X-window based environment.

**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Modeling and Simulation, Computing and Software

**KEYWORDS:** Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

### INTERNET WORKING ANALYSIS FOR COUNTERNARCOTICS INFORMATION OPERATIONS

John McEachen, Assistant Professor  
Department of Electrical and Computer Engineering  
Sponsor: National Security Agency

**OBJECTIVE:** To develop methods for non-traditional analysis of computer network topologies, specifically those affiliated with the Internet. To recommend means for advanced use of network information in information operations. This work is a part of a continuing project with the National Security Agency (NSA).

**SUMMARY:** This project examines computer network topologies and operations in support of national security interests and is largely classified in nature. Recent initiatives within NSA have produced highly unique data requiring more powerful analysis techniques. The initial stages of this research involved identifying key participants with a potential interest in this information. Additionally, specific areas for investigation were identified for further pursuit by NPS students. Finally, a specific NPS student was identified to conduct analysis of current data and apply it to the area of interest. This student will graduate in September 1998. Ongoing work involves identifying new NPS students for thesis research in the remaining areas of interest and continued analysis of network trends.

## PROJECT SUMMARIES

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**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Modeling and Simulation, Computing and Software

**KEYWORDS:** Information Operations, Internet, Counternarcotics, Network Analysis

### **MODELING AND SIMULATION OF ASYNCHRONOUS TRANFER MODE (ATM) TRANSPORT MECHANISMS IN LARGE-SCALE NETWORKS FOR PROJECTION OF INFORMATION OPERATIONS**

**John McEachen, Assistant Professor**  
**Department of Electrical and Computer Engineering**  
**Sponsor: Naval Engineering Logistics Office**

**OBJECTIVE:** To conduct analysis and evaluation of ATM facilities focusing on vulnerability identification and isolation through development of comprehensive large-scale digital communications network models using MIL3's OPNET network modeling software environment. This work is part of a continuing project with Naval Engineering Logistics Office (NELO).

**SUMMARY:** Initial efforts on this project have involved analysis of topology information provided by the sponsor. Work on this project began in December 1997.

**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Modeling and Simulation, Computing and Software

**KEYWORDS:** Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

### **ORGANIZATIONAL COLLABORATION IN A GLOBALLY NETWORKED ENVIRONMENT**

**John McEachen, Assistant Professor**  
**Department of Electrical and Computer Engineering**  
**Sponsor: IEEE Circuits and Systems Society**

**OBJECTIVE:** To leverage off-cutting edge Internet technology and to develop a network-centric system that facilitates the fundamental processes of conference organization and planning.

**SUMMARY:** Professional society conferences—such as the IEEE International Symposium on Circuits and Systems (ISCAS) or the IEEE Military Communications Conference (MILCOM)—are the primary mechanism for exchanging ideas on cutting edge research of vital interest to DoD. This project has identified and encapsulated the collaboration processes associated with organizing such conferences and created a system for researcher interaction on a global scale via the Internet.

Recent advances in database and networking technology allow the traditional processes for conference collaboration to be migrated to an on-line environment. Specifically, the recent development of multi-part MIME encoding, Adobe Portable Document Format (PDF), and Open Database Connectivity (ODBC) world wide web (WWW) gateways led to the implementation of a prototype system which allowed thousands of conference participants to submit documents using standard WWW browsing software for on-line consideration and review. Further, the review process itself as well as presentation scheduling, receipt verification and acknowledgement, and system administration are all facilitated with this system. Traditionally, this had been a highly labor intensive exercise involving several exchanges via postal mail and considerable expense. Some on-line conference organization systems have been implemented in the past, but none have approached the extent and robustness of the current effort.

## PROJECT SUMMARIES

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### PUBLICATION:

Coffman, J.W. and McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment: Implementation of the ISCAS '98 Internet Services," to appear in the *Proceedings of the 1998 International Symposium on Circuits and Systems*, Monterey, CA, June 1998.

### CONFERENCE PRESENTATION:

McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment: Implementation of the ISCAS '98 Internet Services," to be presented at the 1998 International Symposium on Circuits and Systems, Monterey, CA, June 1998.

### OTHER:

ISCAS '98 WWW, E-mail, and Database Servers (<http://iscas.nps.navy.mil/>). A suite of servers was installed and configured for use by the ISCAS organizing committee and participants. These services included mass e-mail announcements, e-mail for committee members, paper submission, review dissemination and collection, scheduling, database access, and program generation. Records on over 3000 individuals were maintained. Over 1200 papers were collected and reviewed. The WWW site was visited over 300,000 times as of December 1997.

**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Human Systems Interface

**KEYWORDS:** Database, Internet, Common Gateway Interface, World Wide Web (WWW), Networking

## RADIATION HARDENING OF SPACE-BASED ELECTRONIC DEVICES AND SOLAR CELLS

Sherif Michael, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

**OBJECTIVE:** To study the space radiation effects on state-of-the-art solar cells including GaAs and InP cells. To investigate annealing methods developed in previous NPS research on the recovery of radiation degraded performance of advanced space cells and develop radiation hardened Analog VLSI circuits for space applications.

**SUMMARY:** Continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include optimizing current annealing methods previously developed for GaAs cells. The tasks also include investigating of the new laser annealing technique on GaAs and InP solar cells. Irradiating solar cells using NPS Linear Accelerator, and measuring their characteristics using the newly developed Solar Simulator Facilities. Other tasks are to investigate radiation effects on different electronic devices. Radiation testing of Analog VLSI chips previously designed and fabricated, using the NPS Linear Accelerator. Major Research: 1) annealing of radiation-damaged solar cells, 2) investigating of Laser Annealing techniques for radiation-damaged solar cells, and 3) radiation tolerant ASIC and analog IC design, implementation and testing.

### PUBLICATIONS:

Michael, S., Shehata, K., and Fouts, D., "Analog/Digital Gallium Arsenide Circuits and Systems Design," *Proceedings of the 40<sup>th</sup> Midwest Symposium on Circuits and Systems*, Sacramento, CA, August 1997.

Michael, S., Shehata, K., and Fouts, D., "Dynamic Logic Families for Complementary Gallium Arsenide (CgaAs) Fabrication Processes," *Proceedings of the 40<sup>th</sup> Midwest Symposium on Circuits and Systems*, Sacramento, CA August 1997.

## PROJECT SUMMARIES

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Michael, S. and Oldland, H., "A GaAs Mixed Mode Switched Capacitor VLSI," *Proceedings of the 40<sup>th</sup> Midwest Symposium on Circuits and Systems*, Sacramento, CA, August 1997.

### CONFERENCE PRESENTATION:

Michael, S., "A GaAs Mixed Mode Switched Capacitor VLSI," 40<sup>th</sup> Midwest Symposium on Circuits and Systems, Sacramento, CA, August 1997.

### THESES DIRECTED:

Oldland, H., "The VLSI Implementation of a GaAs GIC Switched Capacitor Filter," Master's Thesis, Naval Postgraduate School, June 1997.

Reason, J., "A Comparative Study of Nuclear Technology and Direct Energy Conversion Methods for Space Power Systems," Master's Thesis, Naval Postgraduate School, June 1997.

**DoD KEY TECHNOLOGY AREA:** Other (Environmental Effects)

**KEYWORDS:** Space Radiation Effects, Satellites, Annealing Radiation Hardened

### UNINTERRUPTABLE POWER SUPPLY DESIGN FOR THE AN/MRC 142-COMMUNICATION SYSTEM

Sherif Michael, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Marine Corps Systems Command

**OBJECTIVE:** To design and develop a prototype uninterruptable power supply. The result would be an improved power distribution panel that will provide the capability to manually switch between two AC sources, to the HMMWV DC battery/alternator or other DC sources. This would be accomplished with no interruption in the AN/MRC-142 communication system operation.

**SUMMARY:** The research project tasks can be summarized as follows:

- 1) Analyze and study the current existing AN/MRC-142 Power Distribution Panel.
- 2) Design and develop an Uninterruptable Power Supply that will perform the following functions:
  - Convert the selected ac source to 28v dc according to specifications.
  - Respond to monitor signals and initiate or terminate HMMWV charging.
  - Manual override switch for selection between either ac generator.
  - Automatic switching between either generator and the HMMWV Batteries.
  - Display panel for monitoring of the UPS operations.
  - Protection against overvoltage of the ac generators.
- 3) Modify the existing PDP to accommodate the above design within the same panel.
- 4) Complete implementation and testing of the developed UPS.

### THESIS DIRECTED:

Callahan, W., "The Design, Implementation, and Testing of an Uninterruptable Power Supply for the AN/MRC-142 UHF Radio System," Master's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREA:** Electronics

**KEYWORDS:** AN/MRC-142 USMC Communications System, Uninterruptable Power Supply

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## PROJECT SUMMARIES

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### **A HIGH DATA RATE COFDM MODE FOR UHF LINE-OF-SIGHT COMMUNICATIONS IN A MARITIME ENVIRONMENT**

**Paul H. Moose, Associate Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Space and Naval Warfare Systems Center-San Diego**

**OBJECTIVE:** Investigation of high data rate (1.544 Mbps) modem designs for a LOS UHF Naval battle group communications network. The modems will be based on coded orthogonal frequency division multiplexing (COFDM). Appropriate guard intervals, error control coding and interleaving will be determined based on NRaD provided channel information, simulation will be used to optimize system parameters.

**DoD KEY TECHNOLOGY AREA:** Command, Control, and Communications

**KEYWORDS:** Communications, Wireless, COFDM

### **ELECTROMAGNETIC (EM) SIGNATURE SOURCE MEASUREMENT USING SPATIAL SPECTRAL DOMAIN PROCESSING**

**Michael A. Morgan, Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Office of Naval Research and Naval Postgraduate School**

**OBJECTIVE:** There are three primary objectives of this research: (1) discover a comprehensive theory relating measured EM signatures and source spectral domain radiation contributions on general surfaces; (2) develop enhanced back-propagation algorithms for improved imaging of radiation sources; and (3) validate algorithms using both synthetic data from numerical simulations and measured data from the NPS scattering range and other providers.

Important technical issues involve discovery and development of the most useful technique for implementation with measured data. The form of this transformation is an issue, with integral equation and differential equation (e.g., finite element) based approaches possible, as well as hybrid methods. On-surface descriptions of signature sources can include physical currents or, more generally, equivalent currents (useful for apertures and volume sources such as penetrable composite materials). Algorithm robustness is a most important issue for real-world operation. Error propagation to source images induced by noise and inaccuracies in acquired data requires detailed quantification.

**SUMMARY:** This effort supports future ship survivability by furthering the evolution of measurement procedures and data processing for ship EM signature characterization. Accurate localization and identification of radiation sources from both scattering (RCS) and emitters is essential for their mitigation in the design, construction and maintenance of future low-observable platforms operating in an increasingly sophisticated enemy sensor environment.

#### **PUBLICATION:**

Morgan, M.A., "Electromagnetic Radiation Source Imaging," Project Report No. 2, Office of Naval Research, Code 334, August 1997.

#### **CONFERENCE PRESENTATION:**

Morgan, M.A. and Wawrzyniak, D.J., "Enhanced Electro-Magnetic (EM) Radiation Source Imaging," Progress in Electromagnetics Research (PIER) Symposium, Cambridge, MA, 7-11 June 1997.



## PROJECT SUMMARIES

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### THESIS DIRECTED:

Wawrzyniak, D.J., "Enhanced Electro-Magnetic (EM) Radiation Source Imaging," Master's Thesis, Naval Postgraduate School, June 1997.

**DoD KEY TECHNOLOGY AREA:** Sensors

**KEYWORDS:** Imaging, Back-Propagation, Diffraction Limit

### IMPULSE ANTENNA MODELING

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

**OBJECTIVE:** The goal of this task is to investigate the impulse radiation characteristics of specified antenna structures

**SUMMARY:** Initial wire-grid numerical modeling of antenna structures has been completed using frequency-stepping. Impulse source modeling has been approached independently from both frequency- and time-domains to form Thevenin equivalent circuits for impulsive sources. Responses from these distinct source models have been shown to agree. Impulse response characterization of antenna structures is accomplished via inverse transformation of an equivalent circuit.

**DoD KEY TECHNOLOGY AREA:** Modeling and Simulation

**KEYWORDS:** Impulse Response, Antenna Modeling

### ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

Michael A. Morgan, Professor

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

**OBJECTIVE:** The goal of this project was to perform engineering design for efficient, small-sized prototypical ultra-wideband impulse receiving antennas.

**SUMMARY:** A Method-of-Moments numerical model was developed as an aid to search for optimum geometrical dimensions and resistive tapers to achieve the challenging 10 MHz operation criterion, given the antenna size constraint. Several prototype TEM horns were modeled and performance evaluations conducted. Design specifications were provided to the Army Research Lab for fabrication and testing.

### PUBLICATION:

Morgan, M.A. and Robertson, R.C., "Optimized TEM Horn Impulse Receiving Antenna," in *Ultra-Wideband, Short-Pulse Electromagnetics 3*, L. Carin and L.B. Felsen, eds., Plenum Press, New York, pp. 121-128, 1997.

### THESIS DIRECTED:

Adamiak, D.V., "Transient Field Visualization for Ultra-Wideband Antenna Design," Masters Thesis, Naval Postgraduate School, December 1997.

## PROJECT SUMMARIES

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**DoD KEY TECHNOLOGY AREA:** Sensors

**KEYWORDS:** Ultra-Wideband, Impulse Antennas, TEM Horns

### EXPERIMENTAL INVESTIGATION OF A HIGH-SPEED HIGH-RESOLUTION DIRECTION FINDING ARRAY

Phillip E. Pace, Associate Professor

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force and Naval Postgraduate School

**OBJECTIVE:** A direction finding (DF) antenna employing an optimum symmetrical number system (OSNS) encoding of the interferometer phase response to an incident plane wave was developed. The DF method is capable of providing high resolution instantaneous angle of arrival estimates over a wide field of view. In the study just completed (Phase II), a three-channel array was built, and measurements taken in the NPS anechoic chamber to verify the concept and the array performance capabilities.

**SUMMARY:** Interferometer DF systems provide an emitter's bearing that can be used as a sorting parameter in the identification of radar and communication systems. There is a fundamental tradeoff between the array length and its resolution limit. Conventional techniques to shorten the array lead to ambiguous angle measurements. This research involves the development of a new type of DF array based on the optimum symmetrical number system. The DF antenna architecture being investigated uses the OSNS to decompose the analog spatial filtering operation into a number of parallel sub-operations (moduli) that are of smaller complexity. One two-element interferometer is used for each sub-operation and it only requires a precision in accordance with its modulus. A much higher spatial resolution is achieved after the spatial filtering results of these low precision sub-operations are combined. Thus a very short array can instantaneously determine the direction of arrival for an emitter with high precision.

#### PUBLICATIONS:

Pace, P. E., Styer, D., and Akin, I. A., "A Folding ADC Using a Robust Symmetrical Number System with Gray Code Properties," *Proceedings of the 1998 IEEE International Symposium on Circuits and Systems*, accepted for publication, June 1998.

Pace, P. E., Styer, D., and Ringer, W. P., "Optimum SNS to Binary Conversion Algorithm and FPGA Realization," *Proceedings of the 1998 IEEE International Symposium on Circuits and Systems*, accepted for publication, June 1998.

#### OTHER:

Pace, P. and Jenn, D., "Experimental Investigation of a High-Speed High-Resolution Direction Finding Array," Progress Report, 1 July 1997.

#### PATENT:

Pace, P. E., "High Resolution Encoding Circuit and Process for Analog to Digital Conversion," U.S. Patent Number 5,617,092, 1 April 1997.

#### THESES DIRECTED:

Akin, I.A., "A Robust Symmetrical Number System With Gray Code Properties for Applications in Signal Processing," Master's Thesis, Naval Postgraduate School, September 1997.

## PROJECT SUMMARIES

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Papandreou, P., "Design and Prototype Development of an Optimum Symmetrical Number System Direction Finding Array," Master's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Modeling and Simulation

**KEYWORDS:** Array Antennas, Direction Finding, Symmetrical Number Systems

### OPTICAL SAMPLING OF MICROWAVE SIGNALS

Phillip E. Pace, Associate Professor

John Powers, Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

**OBJECTIVE:** To study the issues involved in using optical pulses from a mode-locked laser to sample radio frequency and microwave signals using electro-optical devices. Optical oversampling and undersampling architectures were to be studied. Also, nonuniform sampling theory formulation of the jitter phenomenon was to be studied.

**SUMMARY:** The pulse width and jitter power of the various lasers as reported in the literature were examined in order to study their applicability for use as a wideband signal sampling source. A mode-locked fiber sigma laser has been designed for use in studying the effects of laser pulse sampling of wideband signals. This laser configuration is promising for direct signal sampling since the jitter component has been estimated at less than 200 fs. In addition, optical techniques for measuring the output of the mode-locked lasers have been reviewed. For higher resolution in the detected optical pulse, several optical oversampling (sigma-delta) architectures have been investigated. These optical processors conveniently trade off sampling rate for resolution. Simulation studies were conducted to determine the required coupling coefficients for the fiber lattice configurations. Both first- and second-order, single-bit architectures have been investigated. These architectures are encouraging because they relax the mode-locked laser pulse jitter requirements since the sampling errors are integrated out of the signal band using feedback. If the signal is sampled below the Nyquist rate (undersampling), frequency ambiguities arise. In our work, the symmetrical number system (SNS) was found to have the same form as the discrete Fourier transform (DFT). Using this relationship, DFT receivers have been designed to resolve the undersampling ambiguities exactly. Several optical DFT receivers have been initially investigated. Nonuniform sampling theory has also been investigated as a formulation to describe the effects of sampling jitter that occur due to laser noise. Iterative algorithms for removing the jitter component from the sampled signal have also been initially investigated.

### PUBLICATIONS:

Pace, P.E., Ringer, W.P., Foster, K.D., and Powers, J.P., "Optical Signal Integrity and Interpolation Signal Processing in Wideband SNS Digital Antennas," *Proceedings of the 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, pp. 112-117, 13 January 1997.

Pace, P.E., Atherton, A.F., and Powers, J.P., "Integrated Optical Accumulators with Applications in Sigma Delta Modulation," *Proceedings of the 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, pp. 150-154, 13 January 1997.

Pace, P.E., Leino, R., and Styer, D., "Use of the Symmetrical Number System in Resolving Single Frequency Undersampling Ambiguities" *IEEE Transactions on Signal Processing*, Vol. 45, pp. 1153-1160, May 1997.

### CONFERENCE PRESENTATIONS:

Pace, P.E., Ringer, W.P., Foster, K.D., and Powers, J.P., "Optical Signal Integrity and Interpolation Signal Processing in Wideband SNS Digital Antennas," 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Monterey, CA, 13 January 1997.

## PROJECT SUMMARIES

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Pace, P.E., Atherton, A.F., and Powers, J.P., "Integrated Optical Accumulators with Applications in Sigma Delta Modulation," 7th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Monterey, CA, 13 January 1997.

Pace, P.E., "Optical Sampling and Direct Digitization of Wideband Antenna Signals," Naval Surface Warfare Center-Crane, Monterey, CA, 30 September 1997.

### THESES DIRECTED:

Atherton, A.F., "Integrated Optical Fiber Lattice Accumulators," Master's Thesis, Naval Postgraduate School, March 1997.

Foster, K.D., "A 3-Channel 14-Bit Optimum SNS Wideband Digital Antenna: Analysis of the Electro-Optic Sampling Front-End," Master's Thesis, Naval Postgraduate School, September 1997.

Ringer, W.P., "Design, Construction and Analysis of a 14-Bit Direct Digital Antennal Utilizing Optical Sampling and Optimum SNS Encoding," Master's Thesis, Naval Postgraduate School, September 1997.

**DoD KEY TECHNOLOGY AREA:** Sensors, Electronic Warfare, Other (Optics)

**KEYWORDS:** Optical Sampling, Undersampling, Oversampling, Jitter

### IMPROVEMENT IN ANTI-SHIP CRUISE MISSILE (ACSM) THREAT SIMULATOR MODELING AND SIMULATION TECHNOLOGY

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

**OBJECTIVE:** To continue the effort to develop signal processing routines to improve effectiveness calculations (miss distance) for ship board self-defense systems against hardware-in-the-loop (HIL) anti-ship cruise missile (ASCM) simulators. A second continuing objective in support of the DoN's ASCM Simulator Validation Working Group is the development of software routines that automatically extract a number Electronic Warfare Integrated Reprogrammable Database (EWIRDB) parameters from simulator characterization data obtained in the Naval Research Laboratory (NRL) Central Target Simulator (CTS) anechoic chamber facility.

**SUMMARY:** Distributed sensor, time-space-position information algorithms were further developed for the NRL P-3 research aircraft. These algorithms fuse together the aircraft's onboard global positioning system data, the inertial navigation system data and the HIL missile simulator targeting files in order to graphically display (and tag) in geodetic coordinates, the experimental results from the captive-carry range tests. Lever-arm corrections were computed for each HIL missile simulator and its corresponding mount position on the NRL P-3 research aircraft. To evaluate the differences between the captive-carry missile experiments and an actual threat engagement, computer simulations of a missile attack on a ship that fires a NULKA were carried out in a classroom computer assignment (EC3700). Evaluation of the seeker response as a function of the test geometry was investigated. Correlation of the seeker response curves provided further insight into how effectiveness calculations can be accurately obtained from the captive-carry experiments. To help support the DoN's ASCM simulator validation effort, software routines to extract five additional EWIRDB parameters from the simulator's CTS characterization data were added to the Automatic Extraction of Threat Simulator Critical Parameters (AETSCP) software. The AETSCP version 2.0 now extracts 44 EWIRDB parameters automatically and compares them with the values contained within the intelligence database.

### PUBLICATIONS:

Gill, C.W. and Pace, P.E., "Neural Prediction of Missile Dynamics During Hardware in the Loop Captive-Carry Experiments," *Proceedings of the IEEE International Conference on Neural Networks*, pp. 2208-2212, Houston TX, June 1997.

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## PROJECT SUMMARIES

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Pace, P.E., Nishimura, B.H., Morris, W.M., and Surratt, R.E., "Effectiveness Calculations in Captive-Carry HIL Missile Simulator Experiments," *IEEE Transactions on Aerospace and Electronic Systems*, February 1997.

Pace, P.E., Welch, M., and Zulaica, D., "AETSCP Matlab Toolbox Version 2.0," Naval Research Laboratory *NRL Memorandum Code 5760*, 10 March 1997.

Pace, H., Robertson, R.C., and Pace, P.E., "Frequency Management and Anti-Jam Communication Technologies for the Battlefield," *Proceedings of the 1997 Association of Old Crows Western Region IW Technical Symposium*, pp. 229-235, San Antonio, TX, April 1997.

Pace, P.E., "Distributed Sensor TSPI Algorithm P-3 Implementation," Naval Research Laboratory *NRL Memorandum Code 5760*, 5 August 1997.

Pace, P.E., and Zulaica, D.P., "Automatic Extraction of Threat Simulator Critical Parameters Matlab Toolbox," Naval Postgraduate School Technical Report, NPS-EC-97-012, October 1997.

Pace, H. and Pace, P. E., "Frequency Management for the 21st Century," *Journal of Electronic Defense*, accepted for publication, December 1997.

### CONFERENCE PRESENTATIONS:

Gill, C.W. and Pace, P.E., "Neural Prediction of Missile Dynamics During Hardware in the Loop Captive-Carry Experiments," poster presentation, 1997 IEEE International Conference on Neural Networks, Houston, TX, 9 June 1997.

Pace, H., Robertson, R.C., and Pace, P.E., "Frequency Management and Anti-Jam Communication Technologies for the Battlefield," 1997 Association of Old Crows Western Region IW Technical Symposium, San Antonio, TX, 21 April 1997.

Pace, P.E. and Welch, M.J., "AETSCP Version 2.0," Simulator Validation Working Group, Naval Research Laboratory, Washington, DC, 12 May 1997.

### THESIS DIRECTED:

Welch, M.J., "Automatic Extraction of Threat Simulator Critical Parameters Version 2.0 (U)," Master's Thesis, Naval Postgraduate School, June 1997, (SECRET).

### OTHER:

Pace, P.E., "Automatic Extraction of Threat Simulator Critical Parameters Version 2.0," Matlab Software, June 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Electronic Warfare, Modeling and Simulation

**KEYWORDS:** Time-Space-Position Information, Sensor Fusion, EWIRDB, Hardware-in-the-Loop, Missile Simulation, Effectiveness Calculations

## PROJECT SUMMARIES

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### **MULTI-TARGET/MULTI-SENSOR FUSION PROCESSING TECHNIQUES**

**Harold Titus, Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Naval Research Laboratory**

**OBJECTIVE:** CAPT Richard Williamson and LT Mike Fallon finished work on the emitter location algorithms project. One of the central problems in initializing the location and associating it with an existing file of targets of interest. This still requires more work. We will provide a general sensor fusion algorithm (via extended Kalmar filtering). This should give geolocations based on observations of interest. Implementing the algorithm is hypothesized with differential GPS units collocated with the sensors.

**DoD KEY TECHNOLOGY AREA:** Other (Communications Networking)

**KEYWORDS:** Extended Kalmar Filtering, Sensor Fusion, FFT Processing, Neural Networks

### **BEARTRAP POST-MISSION ANALYSIS SYSTEM**

**Murali Tummala, Professor**

**Charles W. Therrien, Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Advanced Maritime Projects Office and Naval Postgraduate School**

**OBJECTIVE:** To design and develop a signal processing system capable of implementing narrowband frequency tracking, multi-target tracking, wideband and swath processing, transient analysis, and data fusion for the Beartrap post-mission analysis.

**SUMMARY:** The system is being developed based on commercial-off-the-shelf technology: PentiumPro based PC with Windows NT operating system. The user interface is being developed using Microsoft Visual C++, and all the processing algorithms are being coded in the C++ language as well.

During 1997, several user interface screens have been designed. Hardware interface designs have been developed and partially implemented. The narrowband analysis software (AQL) modules have been developed in C++ to carryout filter and decimation, multi-target tracking, frequency track estimation, and SPL estimation functions. Some of these functions were tested by porting the code to the DSP hardware system based on SHARC DSP processors. Work has been carried out on transient analysis algorithms.

#### **THESES DIRECTED:**

Horning, Eric R., "Implementation of Narrowband SPL Estimation Algorithm in a Personal Computer Environment," Master's Thesis, Naval Postgraduate School, September 1997.

Mauser, J.D., "Development of an Acoustic Transient Analysis user Interface for Detection and Target Localization," Master's Thesis, Naval Postgraduate School, December 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Computing and Software, Human Systems Interface, Surface/Under Surface Vehicles - Ships and Watercraft

**KEYWORDS:** Signal Processor Design, Acoustic Signal Processing, Graphical User Interface Design

## PROJECT SUMMARIES

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### PREDISTORTION TECHNIQUES FOR HIGH POWER AMPLIFIERS

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

**OBJECTIVE:** To develop new techniques for predistortion of high power amplifiers used in line of sight wireless links. Earlier effort was based on neural network, polynomial approximation, and Volterra methods.

**SUMMARY:** During 1997, work was continued on a Volterra series based algorithm to directly estimate the inverse power amplifier model parameters, which were then used to realize the predistorter. Experiments were conducted to test the order of nonlinearity and the depth of memory needed to satisfactorily compensate the power amplifier nonlinear behavior. A FET power amplifier simulated in P-Spice was considered for obtaining data for testing the algorithm.

#### PUBLICATION:

Tummala, M., Donovan, M., Watkins, B., and North, R., "Predistortion of High Powered Amplifiers Using Inverse Volterra Modeling," *Proceedings of the 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing*, Munich, Germany, 21-24 April 1997.

#### CONFERENCE PRESENTATION:

Tummala, M., Donovan, M., Watkins, B., and North, R., "Predistortion of High Powered Amplifiers Using Inverse Volterra Modeling," 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing, Munich, Germany, 21-24 April 1997.

**DoD KEY TECHNOLOGY AREAS:** Sensors, Command, Control, and Communications

**KEY WORDS:** High Power Amplifiers, Wireless Communications, Predistortion

### DATA FUSION ALGORITHMS FOR VESSEL TRAFFIC SYSTEM

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Coast Guard

**OBJECTIVE:** To develop data fusion algorithms based on fuzzy association techniques for use in U.S. Coast Guard vessel traffic system upgrade project.

**SUMMARY:** Vessel Traffic System (VTS) receives data from multiple sensors of different types: multiples radars, differential global positioning system based ADS receivers, acoustic sensors, and synthetically generated standard routes. Multiple sensors tracking the same target generate a large amount of redundant data. Here we have developed fuzzy association based algorithms to fuse data from multiple sensors. The algorithm was tested using field recorded data from Puget Sound, WA.

#### PUBLICATIONS:

Aziz, A., Tummala, M., and Cristi, R., "Optimal Data Fusion Strategies for Multiple Sensor Systems," *Proceedings of the 31<sup>st</sup> Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, 2-5 November 1997.

Tummala, M., Midwood, S., and Glenn, I., "Multisensor Data Fusion Using Fuzzy Associative Techniques," *Proceedings of the 1997 Midwest Symposium on Circuits and Systems*, August 1997.

## PROJECT SUMMARIES

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Tummala, M. and Midwood, S., "Multisensor Data Fusion for the Vessel Traffic System," Naval Postgraduate School Technical Report, under preparation, January 1998.

**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Sensors

**KEYWORDS:** Data Fusion, Fuzzy Logic, Multiple Sensors

### OPNET SIMULATION OF A MACRO-CELL WIRELESS NETWORK

**Murali Tummala, Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: Space and Naval Warfare Systems Center-San Diego**

**OBJECTIVE:** To develop OPNET simulation and modeling of a macro-cell wireless communications network for integrated services (speech and data).

**SUMMARY:** This work supported the Space and Naval Warfare Systems-Naval Research Laboratory (NRL) joint effort on expeditionary warfare mobile networking. Developed a completed simulation module in OPNET for a DS-CDMA based macro-cell for combined speech and data services.

#### **PUBLICATIONS:**

Uziel, A. and Tummala, M., "Modeling of Low Data Rate Services for Mobile ATM," *Proceedings of 1997 International Symposium on Personal, Indoor and Mobile Radio Communications*, pp. 194-198, Helsinki, Finland, 1-4 September 1997.

Uziel, A. and Tummala, M., "Protocol Architecture for Tactical Integrated Services Mobile Networks," *Proceedings of MILCOM'97*, pp. 1532-1536, Monterey, CA, 2-5 November 1997.

#### **THESIS DIRECTED:**

Standfield, R., "OPNET Implementation of Spread Spectrum Network for Voice and Data Distribution," Master's Thesis, Naval Postgraduate School, December 1997.

**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communications, Computing and Software

**KEYWORDS:** Code Division Multiple Access, Wireless Communication Networks, Asynchronous Transfer Mode, Integrated Services Digital Networks

### LORAN-C: CALOC TIME DIFFERENCE ERROR CONTROL

**Murali Tummala, Professor**

**Department of Electrical and Computer Engineering**

**Sponsor: U.S. Coast Guard**

**OBJECTIVE:** To develop algorithms for estimation and control of time difference error in LORAN-C receivers to replace the existing CALOC system.

**SUMMARY:** This work is part of the Coast Guard's Loran-C reengineering effort, both transmitter and receiver circuits. Two algorithms (proportional integral differential controller and Kalman filter) were developed for improved estimates of time difference error in the receiver to replace the existing algorithm (called CALOC).



## PROJECT SUMMARIES

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**DoD KEY TECHNOLOGY AREAS:** Command, Control, and Communications

**KEYWORDS:** Time Difference Error, PID Controller, Kalman Filter

### SEU IMMUNE LOW TEMPERATURE GROWN GaAs INTEGRATED CIRCUITS

Todd Weatherford, Assistant Professor

Douglas Fouts, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Space and Naval Warfare Systems Command, Naval Research Laboratory, and  
Naval Postgraduate School

**OBJECTIVE:** To harden digital gallium arsenide (GaAs) integrated circuits to space radiation by reengineering semiconductor starting material.

**SUMMARY:** The purpose of the program is to implement changes in the semiconductor material in GaAs digital fabrication processes to radiation harden circuits against single event upsets (or soft errors) induced by cosmic radiation. The growth of a sub micron thickness buffer layer internal to a GaAs wafer is utilized to increase recombination of charge induced by high energy penetrating particles. Earlier results in this program with Honeywell has shown that the sensitivity of space-based GaAs ICs can be reduced by 5 to 8 orders of magnitude, sufficiently greater than the 3 to 5 orders of magnitude needed for present digital GaAs technologies. However, manufacturing GaAs ICs over these buffer layers must not require substantial changes in present processing. In addition, the reproducibility of the buffer layers and epitaxial material above the buffers must be consistent from wafer lot to wafer lot grown by commercial GaAs wafer vendors (QED and Picogiga). Efforts in FY97 have focused closely on the effects of implementing the buffer layer to improve yield and performance in both the Motorola and Vitesse GaAs processes.

### PUBLICATIONS:

Fouts, D.J., Weatherford, T.R., Dale, C.J., Marshall, P.W., Dietrich, H.B., McMorrow, D., Abrokwhah, J., LaMacchia, M., and Milano, R., "Soft-Error Immune Gallium Arsenide ICs Using COTS Designs and Foundries," *Government Microcircuit Applications Conference*, pp. 93-96, Las Vegas, NV, 10-13 March 1997.

LaMacchia, M., Abrokwhah, J., Bernhardt, B., Foster, D., Crawforth, B., Mathes, B., McGuire, T., and Weatherford, T., "Radiation Hardened Complementary GaAs (CGaAsTM)," *IEEE GaAs IC Symposium Technical Digest*, October 1997.

McMorrow, D., Melinger, J.S., Knudson, A.R., Buchner, S., Tran, L.H., Campbell, A.B., Weatherford, T.R., Fouts, D.J., and Curtice, W.R., "Development of a High-Performance Radiation-Immune GaAs Technology Using Low-Temperature Grown GaAs," *Ultrafast Phenomena Workshop*, 18 March 1997.

Pieper, R.J. and Weatherford, T.R., "An Exact Analysis for Bimolecular Band-to-Band Recombination Lifetime Under High Injection Conditions," *Proceedings of the 29th Southeastern Symposium on System Theory*, 9-11 March 1997.

Weatherford, T.R., Marshall, P.W., Marshall, C.J., Fouts, D.J., Mathes, B., and LaMacchia, M., "Effects of Low-Temperature Buffer-layer Thickness and Growth Temperature on the SEE Sensitivity of GaAs HIGFET Circuits," *IEEE Transactions on Nuclear Science*, NS-45, December 1997.

Weatherford, T.R., Radice, R., Devers, J., Eskins, D., Fouts, D.J., Marshall, P.W., Marshall, C.J., Dietrich, H., Twigg, M., and Milano, R., "SEU Design Considerations for MESFETs on LT GaAs," *IEEE Transactions on Nuclear Science*, NS-45, December 1997.

Weatherford, T.R., Fouts, D.J., Marshall, P.W., Marshall, C.J., and Dietrich, H., "Soft Error Immune GaAs Circuit Technologies," *Proceeding of the 1997 Midwest Symposium on Circuits and Systems*, August 1997.

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## PROJECT SUMMARIES

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### CONFERENCE PRESENTATIONS:

Fouts, D.J., Weatherford, T.R., Marshall, P.W., Marshall, C.J., Dietrich, H.B., Twigg, M., LaMacchia, M., Abrokwha, J., and Milano, R., "Low-Temperature Gallium Arsenide Soft-Error Immune Digital Integrated Circuits," 1997 Radiation Environmental Effects Forum, Chantilly, VA, 25-27 February 1997.

Pieper, R.J. and Weatherford, T.R., "An Exact Analysis for Bimolecular Band-to-Band Recombination Lifetime Under High Injection Conditions," 29<sup>th</sup> Southeastern Symposium on System Theory, 9-11 March 1997.

Weatherford, T.R., Marshall, P.W., Marshall, C.J., Fouts, D.J., Mathes, B., and LaMacchia, M., "Effects of Low-Temperature Buffer-layer Thickness and Growth Temperature on the SEE Sensitivity of GaAs HIGFET Circuits," poster presentation, IEEE Natural Space Radiation Effects Conference, Snowmass Village, CO, 21-25 July 1997.

Weatherford, T.R., Radice, R., Devers, J., Eskins, D., Fouts, D.J., Marshall, P.W., Marshall, C.J., Dietrich, H., Twigg, M., and Milano, R., "SEU Design Considerations for MESFETs on LT GaAs," IEEE Natural Space Radiation Effects Conference, Snowmass Village, CO 21-25 July 1997.

Weatherford, T.R., Fouts, D.J., W.Marshall, P.W., Marshall, C.J., and Dietrich, H., "Soft Error Immune GaAs Circuit Technologies," Midwest Symposium on Circuits and Systems, Sacramento, CA, 3 August 1997.

### PATENT:

Weber, E., Specht, P., and Weatherford, T.R., "III-V Device Buffer Layers Using Dopants During Low Temperature Growth," November 1997.

### THESES DIRECTED:

Eskins, D., "Design and Simulation of a Low Temperature GaAs MESFET," Master's Thesis, Naval Postgraduate School, June 1997.

Radice, R., "Single Event Analysis of LT GaAs MESFET Integrated Circuits," Master's Thesis, Naval Postgraduate School, September 1997.

Schumberger, M., "Single Event Analysis of Low Temperature Gallium Arsenide Field Effect Transistor Technology," Master's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREAS:** Space Vehicles, Electronics, Materials, Processes and Structures, Manufacturing Science and Technology, Modeling and Simulation

**KEYWORDS:** Gallium Arsenide, Radiation Effects, Semiconductors

**HIGH PERFORMANCE, RADIATION HARDENED  
INTEGRATED CIRCUIT (IC) TECHNOLOGIES**  
Todd Weatherford, Assistant Professor  
Department of Electrical and Computer Engineering  
Sponsor: Naval Postgraduate School

**OBJECTIVE:** To investigate the radiation hardness of InP, GaAs and SiGe state-of-the-art electronic technologies for use in military space environments.

## PROJECT SUMMARIES

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**SUMMARY:** Experiments utilized femtosecond lasers with photoconductive sampling probes to measure the first recorded radiation induced in-situ voltage transients internal to an integrated circuit. Facilities at the University of Michigan's Center of Ultrafast Science were utilized for the laser experiments and computer modeling of the underlying charge transport mechanisms were performed at NPS. The research examined three types of technologies, the Vitesse digital GaAs process and Hughes InP Heterojunction and IBM SiGe bipolar processes. Successful results have enabled the radiation effects community to use this technique to understand the effects of cosmic ray interaction on digital circuits operating at gigahertz frequencies. Additionally the program has been expanded to include other sponsors in FY98.

### PUBLICATIONS:

David, G., Hayden, J., Lai, R.K., Ledbetter, E.J., Weatherford, T.R., Fouts, D., and Whitaker, J.F., "Detection of Optically Induced Single-Event Effects Inside Digital Circuits Using a Micromachined Photoconductive Probe," *Proceedings of the 1997 Laser Electro Optics Conference*, San Francisco, CA, November 1997.

Ledbetter, E.J., Weatherford, T.R., David, G., Hayden, J., Lai, R., Whitaker, J., and Fouts, D., "In Situ Picosecond Resolution Measurements of Charge Collection Transients in GaAs Logic," 2<sup>nd</sup> review, *IEEE Transactions on Nuclear Science*.

Weatherford, T.R., David, G., Whitaker, J., Jobe, K., and Elliott, K., "Charge Collection in InP Heterojunction Bipolar Circuits," to be submitted to the *IEEE Transactions on Nuclear Science*.

### CONFERENCE PRESENTATIONS:

David, G., Hayden, J., Lai, R.K., Ledbetter, E.J., Weatherford, T.R., Fouts, D., and Whitaker, J.F., "Detection of Optically Induced Single-Event Effects Inside Digital Circuits Using a Micromachined Photoconductive Probe," 1997 Laser Electro Optics Conference, San Francisco, CA, November 1997.

Ledbetter, E.J., Weatherford, T.R., David, G., Hayden, J., Lai, R., Whitaker, J., and Fouts, D., "In Situ Picosecond Resolution Measurements of Charge Collection Transients in GaAs Logic," poster presentation, IEEE Natural Space Radiation Effects Conference, Snowbird, UT, July 1997.

### THESIS DIRECTED:

Ledbetter, E., "Field-Sensitive Photoconductive Sampling Probe Measurements of a Single Event Upset," Master's Thesis, Naval Postgraduate School, June 1997.

**DoD KEY TECHNOLOGY AREAS:** Electronics, Materials, Processes and Structures, Modeling and Simulation

**KEYWORDS:** Radiation Effects, Indium Phosphide, Gallium Arsenide

### COORDINATION OF MOBILE MANIPULATORS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: National Science Foundation

**OBJECTIVE:** The objective of this project is to investigate control algorithms for coordinating locomotion and manipulation of mobile manipulators.

**SUMMARY:** A mobile manipulator consisting of a mobile platform and a manipulator combines the dexterous manipulation capability offered by a multi-link manipulator and the mobility provided by a mobile platform. Integration of a manipulator and a mobile platform, however, gives rise to many new issues. In this project, a family of control algorithms were developed for coordinating locomotion and manipulation, based on a novel concept of the preferred operating regions.

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## PROJECT SUMMARIES

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These algorithms were implemented on an experimental mobile manipulator and shown to be very effective in performing various tasks. Dynamic interactions between a mobile platform and its onboard manipulator were investigated. The effect of dynamic interactions on tracking accuracy was obtained. Criteria were established for proper compensation of interactive forces with respect to task requirements. Using superquadric potential functions, an obstacle avoidance scheme for mobile manipulators was developed and integrated with coordinated control algorithms. A control algorithm for coordinating two mobile manipulators was also developed and tested on an experimental system. The system successfully performed a variety of tasks including transporting basketballs and large cartons from one location to another.

### PUBLICATIONS:

Sarkar, N., Yun, X., and Kumar, V., "Control of Contact Interactions with Acatastatic Nonholonomic Constraints," *International Journal of Robotics Research*, Vol. 16, No. 3, pp. 357-374, June 1997.

Yamamoto, Y. and Yun, X., "A Modular Approach to Dynamic Modeling of a Class of Mobile Manipulators," *International Journal of Robotics and Automation*, Vol. 12, No. 2, pp. 41-48, 1997.

Yun, X. and Yamamoto, Y., "Stability Analysis of the Internal Dynamics of a Wheeled Mobile Robot," *Journal of Robotic Systems*, Vol. 14, No.10, pp. 697-709, October 1997.

### THESIS DIRECTED:

Gerrard, D., "Dynamic Control of a Vehicle with Two Independent Wheels," Master's Thesis, Naval Postgraduate School, September 1997.

**DoD KEY TECHNOLOGY AREA:** Sensors, Ground Vehicles, Modeling and Simulation

**KEYWORDS:** Mobile Manipulators, Coordination, Control

### CISE RESEARCH INSTRUMENTATION: EXPERIMENTAL STUDY OF MULTIPLE MOBILE MANIPULATORS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: National Science Foundation

**OBJECTIVE:** The objective of this equipment grant was to support three research projects: (1) force and motion control for intelligent exploration of environments; (2) coordination of locomotion and manipulation; and (3) coordination of multiple mobile manipulators.

**SUMMARY:** All three projects have been successfully carried out. Significant results have been obtained. First, a new force/motion control algorithm based on impulsive constraint analysis was developed and experimentally validated. This algorithm eliminates control discontinuities present in most other force controllers. Second, a family of control algorithms were developed for coordinating locomotion and manipulation, based on a novel concept of the preferred operating regions. These algorithms were implemented on an experimental mobile manipulator and shown to be very effective in performing various tasks. Third, a control algorithm for coordinating two mobile manipulators was developed and tested on an experimental system. The system successfully performed a variety of tasks including transporting basketballs and large cartons from one location to another.

### PUBLICATIONS:

Sarkar, N., Yun, X., and Kumar, V., "Dynamic Control of 3-D Rolling Contacts in Two-Arm Manipulation," *IEEE Transactions on Robotics and Automation*, Vol. 13, No. 3, pp. 364-376, June 1997.

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## PROJECT SUMMARIES

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Sarkar, N., Yun, X., and Ellis, R., "Live-Constraint-Based Control for Contact Transitions," *Proceedings of the 1997 IEEE International Symposium on Computational Intelligence in Robotics and Automation*, pp. 353-360, Monterey, CA, July 1997.

Yun, X., Alptekin, G., and Albayrak, O., "Line and Circle Formation of Distributed Physical Mobile Robots," *Journal of Robotic Systems*, Vol. 14, No. 2, pp. 63-76, February 1997.

### CONFERENCE PRESENTATION:

Yun, X., "A Survey of Wheeled Mobile Robots," ICRA'97 Workshop on Innovative Designs of Wheeled Mobile Robots, Albuquerque, NM, 20 April 1997.

**DoD KEY TECHNOLOGY AREAS:** Modeling and Simulation, Other (Robotic Technology)

**KEYWORDS:** Robot Manipulators, Force Control, Impulsive Constraints

### FEATURE-BASED LOCALIZATION AND NAVIGATION OF AUTONOMOUS MOBILE ROBOTS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research

**OBJECTIVE:** To investigate localization and navigation of mobile robots using sonars and laser-range finders.

**SUMMARY:** For an autonomous mobile robot to navigate in an unknown environment, it is essential to know the location of the robot on a real-time basis. Finding position and orientation of a mobile robot in a world coordinate system is a problem in localization. Dead-reckoning is commonly used for localization, but position and orientation errors from dead-reckoning tend to accumulate over time. This project develops a feature-based localization method that allows a mobile robot to re-calibrate its position and orientation by automatically selecting wall-like features in the environment. The selection of features is accomplished by applying the Hough transform to sonar data. The Hough transform makes it possible to select the optimal feature (the longest wall, in this case) without finding all possible line segments from the sonar data. A least-square line fitting method is then employed to construct a model of the line segment that represents the feature selected by the Hough transform. The algorithm developed was tested using synthetic and real sonar data. Experimental results demonstrated the effectiveness of the proposed localization methods.

### PUBLICATION:

Yun, X. and Tan, K.-C., "A Wall-Following Method for Escaping Local Minima in Potential Field Based Motion Planning," *Proceedings of the 8<sup>th</sup> International Conference on Advanced Robotics*, pp. 421-426, Monterey, CA, July 1997.

### CONFERENCE PRESENTATION:

Yun, X., "A Wall-Following Method for Escaping Local Minima in Potential Field Based Motion Planning," 8<sup>th</sup> International Conference on Advanced Robotics, Monterey, CA, July 1997.

### THESES DIRECTED:

Latt, K., "Sonar-Based Localization of Mobile Robots Using the Hough Transform," Master's Thesis, Naval Postgraduate School, March 1997.

## PROJECT SUMMARIES

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Schmidt, J.A., "Design, Construction and Testing of an Autonomous Mine Hunter," Master's Thesis, Naval Postgraduate School, December 1997.

**DoD KEY TECHNOLOGY AREAS:** Ground Vehicles, Other (Robotic Technology)

**KEYWORDS:** Mobile Robots, Localization, Navigation

### WIRELESS DAMAGE CONTROL COMPUTER NETWORK

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Sea Systems Command

**OBJECTIVE:** To develop a wireless computer network for submarine damage control.

**SUMMARY:** Accurate, timely communications between the casualty scene, different stations around the ship, and damage control central (DCC) have always been of the utmost importance when combating shipboard casualties. Current damage control communications practices aboard submarines rely on a slow, error prone process involving sound powered telephone talkers and grease pencil annotated status boards. This project is aimed at greatly improving the speed and reliability of these communications by supplementing the current DCC communication methods with a wireless Local Area Network (LAN) that allows portable computers at the scene of casualty and elsewhere around the ship to remotely update the casualty status at DCC.

#### THESIS DIRECTED:

Bekas, A.J., "Wireless Communications for a Multiple Robot System," Master's Thesis, Naval Postgraduate School, March 1997.

**DoD KEY TECHNOLOGY AREA:** Surface/Under Surface Vehicles – Ships and Watercraft

**KEYWORDS:** Wireless Communications, Damage Control

### CHAOTIC SYNCHRONIZATION FOR SECURE COMMUNICATION

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School

**OBJECTIVE:** To investigate the feasibility of secure communications utilizing synchronization of chaotic dynamic systems.

**SUMMARY:** Application of chaotic synchronization to secure communications was investigated. A system prototype was built for the purpose of validating the concept. The prototype consists of two major subsystems: a chaotic generator and a chaotic synchronizer. The chaotic generator implemented a third-order Lorenz system using analog RC components. An analog voice signal was mixed with chaotic signal and transmitted. The voice signal was recovered at the synchronizer end. The experiment demonstrated that the concept of chaotic synchronization for secure communication was feasible.

#### OTHER:

A prototype of the chaotic system was built and is available for proper certification of chaotic synchronization as an alternative means for secure communications.

## PROJECT SUMMARIES

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**DoD KEY TECHNOLOGY AREAS:** Command, Control and Communication, Electronic Warfare, Electronics

**KEYWORDS:** Secure Communications, Chaotic Synchronization, Chaotic Dynamic Systems, Lorenz System

### **AN INTEGRATED INS/GPS SHALLOW-WATER AUTONOMOUS UNDERWATER VEHICLE NAVIGATION SYSTEM**

**Xiaoping Yun, Associate Professor  
Department of Electrical and Computer Engineering  
Sponsor: Unfunded**

**OBJECTIVE:** The objective of this project is to develop an integrated self-contained shallow-water navigation system for autonomous underwater vehicles (AUV).

**SUMMARY:** A Small AUV Navigation System (SANS) is being developed at the Naval Postgraduate School. The SANS is an integrated GPS/INS navigation system composed of low-cost and small-size components. It is designed to demonstrate the feasibility of using a low-cost strapped-down inertial measurement unit (IMU) to navigate between GPS fixes. The present hardware consists of a GPS/DGPS receiver, IMU, compass, water speed sensor, water depth sensor, and a data processing computer. The software is based on a twelve-state complementary Kalman filter. This paper describes hardware and software design, and testing results of the SANS. It is shown that results from tilt table testing and bench testing provide an effective means for tuning filter gains. Results from ground vehicle testing demonstrate that the SANS is able to navigate 10 meter accuracy for more than three minutes between DGPS fixes.

#### **PUBLICATION:**

Yun, X., Bachmann, E.R., McGhee, R.B., Whalen, R.H., Roberts, R.L., Knapp, R.G., Healey, A.J., and Zyda, M.J., "Testing and Evaluation of an Integrated GPS/INS System for Small AUV Navigation (SANS)," *Proceedings of the 10<sup>th</sup> International Symposium on Unmanned Untethered Submersible Technology (UUST)*, Durham, NH, 7-10 September 1997.

#### **THESES DIRECTED:**

Knapp, R.G., "Calibration and Evaluation of Water Speed Indicator and Compass for the Small Autonomous Underwater Vehicle Navigation Filter," Master's Thesis, Naval Postgraduate School, September 1997.

Young, F., "Distributed Control and Sensing of Autonomous Underwater Vehicles Using LonTalk," Master's Thesis, Naval Postgraduate School, September 1997.

**DoD KEY TECHNOLOGY AREA:** Surface/Under Surface Vehicles – Ships and Watercraft

**KEYWORDS:** IMU, GPS, Navigation, Autonomous Underwater Vehicle

### **RESEARCH ON A SEMI-AUTONOMOUS GROUND AND AERIAL VEHICLE SYSTEM FOR MINE/UNEXPLODED ORDNANCE (UXO) DETECTION AND CLEARING**

**Xiaoping Yun, Associate Professor  
Department of Electrical and Computer Engineering  
Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis**

**OBJECTIVE:** To investigate and develop a semi-autonomous robot system for land mine/UXO searching/processing tasks in humanitarian operations.

## PROJECT SUMMARIES

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**SUMMARY:** This is a multi-disciplinary project involving faculty and students from four NPS departments. The overall goal was to develop a semi-autonomous robotic system for searching land mines and UXOs. A four-wheel-drive and four-wheel-steering vehicle for mine/UXO searching in rough terrains was designed and built. The PI's contribution to the project was in the area of control and navigation of the vehicle. Low-level servo control of the vehicle is implemented and tested. An integrated INS/GPS navigation system was installed. A navigation algorithm that combines readings from shaft encoders, GPS, and inertial sensors is developed and implemented.

**PUBLICATION:**

Kanayama, Y.J. and Yun, X., "Rigid Body Motion Analysis towards Rotary Vehicle," *ICRA'97 Workshop on Innovative Designs of Wheeled Mobile Robots*, Albuquerque, NM, 20 April 1997.

**THESIS DIRECTED:**

Leonardy, T., "Implementation and Evaluation of an INS Navigation System for the Shepherd Mobile Robot," Master's Thesis, Naval Postgraduate School, December 1997.

**DoD KEY TECHNOLOGY AREAS:** Ground Vehicles, Other (Robotic Technology)

**KEYWORDS:** Land Mines, Unexploded Ordnance (UXO), Mobile Robots, Navigation

### SUPPORT OF THE NEAR SHORE TACTICAL RECONNAISSANCE (NSTR) PROGRAM

Lawrence J. Ziomek, Professor

Department of Electrical and Computer Engineering

Sponsors: Defense Advanced Research Projects Agency and Naval Postgraduate School

**OBJECTIVE:** Deliver the recursive ray acoustics (RRA) computer algorithm to the Applied Physics Laboratory-Johns Hopkins University (APL-JHU) in support of the Near Shore Tactical Reconnaissance (NSTR) Program. Be available for consultation to APL-JHU to ensure the successful running, testing, and evaluation of the RRA algorithm. Time permitting, further investigate the use of two-dimensional orthogonal function expansions of noise corrupted and/or uncertain environmental data and incorporate into the existing shallow water pulse-propagation model, which is based on the RRA algorithm. Specifically, fit surfaces to two-dimensional ocean-bottom depth data, that is, bathymetry as a function of cross-range and down-range. Such ocean bottom surface fits allow for the prediction of out-of-plane ray propagation due to bottom bounces which can impact bearing estimation algorithms used for target localization. In addition, fit surfaces to two-dimensional speed-of-sound data, that is, sound speed as a function of depth and down-range.

**SUMMARY:** The recursive ray acoustics (RRA) computer algorithm was delivered to the Applied Physics Laboratory-Johns Hopkins University (APL-JHU) in support of the Near Shore Tactical Reconnaissance (NSTR) Program. The RRA algorithm was run at both NPS and APL-JHU for several identical test cases. The results obtained from running the program at both institutions were exactly the same. Further evaluation and testing of the RRA algorithm at the APL-JHU revealed that higher-order one-dimensional orthogonal function expansions of depth-dependent sound-speed data are required in order to successfully fit complicated sound-speed profiles. As a result, the maximum order fit was increased from 5th-order to 13th-order for both sound-speed and bathymetric data. In addition, Chebyshev polynomials are now used in the Gram-Schmidt procedure to generate the orthogonal polynomials with improved numerical accuracy. The use of the modified Gram-Schmidt orthogonalization technique was also investigated. It did not perform significantly better than simply using Chebyshev polynomials in the Gram-Schmidt procedure to generate the orthogonal polynomials. Finally, automatic 90 degree phase corrections are now made to the phase along a ray path each time a ray path passes through a focal point.



## PROJECT SUMMARIES

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### OTHER:

Ziomek, L.J., "The Recursive Ray Acoustics (RRA) Algorithm," SRI International, Menlo Park, CA, 31 January 1997.

Ziomek, L.J., "Underwater Acoustic Pulse Propagation Using the Recursive Ray Acoustics (RRA) Algorithm," invited speaker at the ONR USW Broadband Processing Working Group, Naval Postgraduate School, Monterey, CA, 10-11 December 1997.

**DoD KEY TECHNOLOGY AREA:** Modeling and Simulation

**KEYWORDS:** Recursive Ray Acoustics (RRA) Algorithm, Orthogonal Function Expansions of Environmental Data, Pulse (Transient) Propagation Modeling, Shallow Water Acoustics, Target Localization

### MATHEMATICAL MODELING OF DOLPHIN BIOSONAR

Lawrence J. Ziomek, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

**OBJECTIVE:** Two major objectives: (1) Derive an accurate and realistic mathematical model for a typical, individual, broadband click pulse that is transmitted by the Atlantic Bottlenose Dolphin (*Tursiops Truncatus*). One way to get a definitive answer as to what kind of amplitude modulation and angle modulation (if any) is present, is to perform a quadrature decomposition on experimental data of individual click pulses transmitted by *Tursiops Truncatus*. A computer program will be written that will perform a quadrature decomposition on the data. (2) Derive accurate and realistic mathematical models of the receive aperture and the corresponding receive, far-field beam pattern of *Tursiops Truncatus*. After the mathematical modeling is done, a computer program will be written to simulate both the receive aperture and the receive, far-field beam pattern. If any experimental data of the frequency response of the receive aperture of a *Tursiops Truncatus* is available, it can be incorporated into the models. Experimental data will be provided by the Tropical Marine Science Initiative (TMSI) of the National University of Singapore.

**SUMMARY:** Work began on the development of a computer program that will perform a quadrature decomposition on experimental data of individual click pulses transmitted by the Atlantic Bottlenose Dolphin (*Tursiops Truncatus*).

**DoD KEY TECHNOLOGY AREAS:** Biomedical, Modeling and Simulation

**KEYWORDS:** Dolphin, Biosonar, Dolphin Biosonar

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- Ha, T.T., Keiser, G.E., and Borchardt, R.L., "Bit Error Probabilities of OOK Lightwave Systems with Optical Amplifiers," *Journal of Optical Communications*, Vol. 18, No. 4, pp. 151-155, August 1997.
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## 1997 THESIS ABSTRACTS

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### **A ROBUST SYMMETRICAL NUMBER SYSTEM WITH GRAY CODE PROPERTIES FOR APPLICATIONS IN SIGNAL PROCESSING**

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**B.S., Turkish Naval Academy, 1991**

**Master of Science in Systems Engineering-September 1997**

**Advisor: Phillip Pace, Department of Electrical and Computer Engineering**

**Second Reader: David Styer, Department of Mathematics, University of Cincinnati**

A new symmetrical number system with applications in parallel signal processing is investigated. The Robust Symmetrical Number System (RSNS) is a modular system in which the integer values within each modulus, when considered together, change one at a time at the next position (Gray code properties). Although the observed dynamic range of the RSNS is somewhat less than the optimum symmetrical number system, the Gray code properties make it particularly attractive for folding analog-to-digital converters. With the RSNS, the encoding errors (due to comparator thresholds not being crossed simultaneously) are eliminated, as is the need for the corresponding interpolation signal processing (reduced complexity). Computer generated data is used to help determine the properties of the RSNS. These properties include the largest dynamic range (number of distinct consecutive vectors), and the position of the largest dynamic range within the system. The position of the maximum unambiguous dynamic range is also quantified. Least squares analysis of 2 and 3 moduli systems is used to formulate closed-form expressions for the dynamic range. To compare the advantages of the RSNS with previously published results, the transfer function of a 3-channel RSNS folding analog-to-digital converter architecture ( $m_1=3$ ,  $m_2=4$ , and  $m_3=5$ ) is numerically evaluated using SPICE.

### **PRACTICAL IMPLEMENTATION OF THE HARD SWITCHED BUCK CHOPPER**

**Kirk D. Allen-Lieutenant Commander, United States Navy**

**B.S., Texas A&M University, 1982**

**Master of Science in Electrical Engineering-March 1997**

**Advisor: Robert W. Ashton, Department of Electrical and Computer Engineering**

**Second Reader: John G. Ciezki, Department of Electrical and Computer Engineering**

As the Navy progresses into the twenty-first century, new concepts in shipboard electrical power management are being explored. One area of significant interest to the Navy is utilization of DC electrical distribution systems rather than traditional AC distribution systems. The DC Zonal Electrical Distribution System is a prime candidate for direct application to modern power distribution. This system employs solid-state conversion devices to supply ships loads from one of two high-voltage DC busses. One such device, a buck chopper, is the focus of this thesis. In order to validate this proposed architecture, the startup and transient performance of these choppers must be explored. The buck chopper incorporates a control technique which employs both voltage and current feedback in conjunction with feed-forward. Specific advantages of this control technique with the buck chopper circuit include power source perturbation rejection, fast dynamic response to both load and source voltage changes and a house curve for parallel buck chopper operation. The design will include both over-current and thermal protection in order to prevent circuit component damage. The focus of this thesis is to validate the predicted operation of this control technique and to verify circuit performance.

### **INTEGRATED OPTICAL FIBER LATTICE ACCUMULATORS**

**Adam F. Atherton-Civilian**

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Sigma-delta modulators track a signal by accumulating the error between an input signal and a feedback signal. The accumulated energy is amplitude analyzed by a comparator. The comparator output signal is fed back and subtracted from the

## 1997 THESIS ABSTRACTS

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input signal. This thesis is primarily concerned with designing accumulators for inclusion in an optical sigma-delta modulator. Fiber lattice structures with optical amplifiers are used to perform the accumulation. Two fiber lattice structures are designed, modeled, tuned, tested, and characterized. The testing results for both models are plotted and tabulated. One result is that accumulation is inversely proportional to coupling ratio. Also, the optical gain necessary to drive either fiber lattice structure to a monotonically increasing response is identical. With less than 10 dB of optical gain, a wide range of accumulation rates are available. Initial integration of one fiber lattice structure into a first-order sigma-delta modulator is accomplished with results consistent with those from an ideal model. The design for a second-order sigma-delta modulator is developed, tested, and preliminary results shown.

### **POWER ELECTRONIC BUILDING BLOCK NETWORK SIMULATION TESTBED STABILITY CRITERIA AND HARDWARE VALIDATION STUDIES**

**Michael G. Badorf-Lieutenant, United States Navy**

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**Master of Science in Electrical Engineering-June 1997**

**Advisor: Robert W. Ashton, Department of Electrical and Computer Engineering**

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Naval power distribution has principally used an AC network to supply loads. With the advent of new power electronic devices, the focus has shifted to employing a DC distribution system that eliminates large transformers and mechanical switching devices and enhances the survivability of the platform. The Power Electronic Building Block (PEBB) Network Simulation Testbed currently under construction at the Naval Postgraduate School is a study into the feasibility of such DC systems.

The objective of this thesis was to perform theoretical and simulation-based analysis to establish quantitative criteria for PEBB Testbed stability. These criteria were then used to develop a set of hardware studies to investigate the interaction of components within the PEBB Testbed. Finally, the hardware studies were utilized to verify PEBB Testbed performance.

Principal conclusions of this research included that the PEBB Test bed demonstrated stability under all simulated loading conditions. Follow-on testing of the PEBB Testbed confirmed that the simulations correlated well with hardware implementation. In addition, the hardware validation studies revealed that switching harmonics had a considerable effect on the system output.

### **DENOISING OF OCEAN ACOUSTIC SIGNALS USING WAVELET-BASED TECHNIQUES**

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**Master of Science in Electrical Engineering-December 1996**

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**Ralph Hippenstiel, Department of Electrical and Computer Engineering**

This thesis investigates the use of wavelets, wavelet packets, and cosine packet signal decompositions for the removal of noise from underwater acoustic signals. Several wavelet based denoising techniques are presented and their performances compared. Results from the comparisons are used to develop a wavelet-based denoising algorithm suitable for a wide variety of underwater acoustic transients. Performances of the denoising algorithm are compared to those of a short-time Wiener filter implementation and demonstrate that wavelet-based methods are a viable tool for the denoising of acoustic data.

## 1997 THESIS ABSTRACTS

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### **WIRELESS COMMUNICATIONS FOR A MULTIPLE ROBOT SYSTEM**

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A multi-disciplinary research project is being undertaken at NPS to develop a semiautonomous robotic system to detect and clear land mines and Unexploded Ordnance (UXO). The robotic system under development consists of a land vehicle, an aerial vehicle, and a ground-based control station. Reliable communication between these three stations is needed. A traditional wire-based network requires that the vehicles be tethered and severely limits the mobility of the vehicles. A wireless Local Area Network (LAN) is proposed to provide communications between the control station and the vehicles.

The objective of this thesis was to develop the physical (hardware) and logical (software) architecture of a wireless LAN that accommodates the needs of the mine/UXO project. Through an analysis of wireless modulation techniques, a market survey of wireless devices, and a field testing of wireless devices, a wireless LAN was designed to meet the technological, performance, regulation, interference, and mobility requirements of the mine/UXO project. Finally, the wireless communication protocols and the development of an error-free application protocol (specified by a FSM model and implemented in ANSI C code using Windows socket network programming) completed the wireless LAN implementation.

### **UNCLASSIFIED FEASIBILITY OF REPLACING OR SUPPLEMENTING THE EA-6B SUPPORT JAMMING SYSTEM USING UAV BASED JAMMER(U)**

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**Second Reader: Donald v.Z. Wadsworth, Department of Electrical and Computer Engineering**

(U) There are increasing demands by theater CINCS for EA-6B Electronic Attack aircraft to provide Stand-Off-Jamming support during peace operations, as well as to protect aircraft which have missions near and within hostile countries. To reduce some of the demands for the EA-6B, large-payload Unmanned Aerial Vehicles (UAVs) containing stand-off Electronic Attack packages are now feasible. This study analyzes the feasibility of replacing or supplementing the EA-6B support jamming system using a UAV based jammer. The Global Hawk UAV with the ALQ-99 Electronic Attack system are the base systems for this study. This added support along with Global Hawks increased connectivity, higher survivability, and long on station time would give the EA-6B added flexibility in its employment against advanced radar and SAM systems. Global Hawk would still perform its primary mission of collecting airborne imagery, when not required to support the Suppression of Enemy Air Defenses. In order to determine the appropriate Concept of Operations for Global Hawk as a Stand-Off-Jammer, this study includes a threat analysis, and a determination of required airframe and electrical modifications.

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## 1997 THESIS ABSTRACTS

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### **CLASSIFICATION OF UNDERWATER SIGNALS USING A BACK-PROPAGATION NEURAL NETWORK**

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This thesis examines a number of underwater acoustic signals and the problem of classifying these signals using a back-propagation neural network. The neural network classifies the signals based upon features extracted from the original signals. The effect on classification by using an adaptive line enhancer for noise reduction is explored. Two feature extraction methods have been implemented: modeling by an autoregressive technique using the reduced-rank covariance method, and the discrete wavelet transformation. Both orthonormal and nonorthonormal transforms are considered in this study.

### **THE DESIGN, IMPLEMENTATION AND TESTING OF AN UNINTERRUPTIBLE POWER SUPPLY FOR THE AN/MRC-142 UHF RADIO SYSTEM**

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**Advisor: Sherif N. Michael, Department of Electrical and Computer Engineering**

**Second Reader: Robert W. Ashton, Department of Electrical and Computer Engineering**

The design of an uninterruptible power supply (UPS) for the United States Marine Corps AN/MRC-142 Ultra High Frequency Radio system is presented. The components of the AN/MRC-142 communications system are analyzed with regard to their power requirements so that the nature of the system's shortcoming can be well understood. The fundamentals of electrical power design and distribution, and basic UPS topologies are presented. Five design alternatives that provide a solution to the identified system shortcoming are presented, tested, and evaluated. The paper concludes with a recommendation to the Marine Corps Systems Command for the UPS alternative that best provides uninterruptible power for the AN/MRC-142.

### **A FUTURE SPACE INTELLIGENCE ARCHITECTURE (U)**

**Michael J. Carlan-Lieutenant, United States Navy**

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**Master of Science in Space Systems Operations-September 1997**

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The existing satellite intelligence architecture is an aggregation of individual systems developed during the Cold War era by separate organizations and for different purposes. Their current operation reflects the singularity of their origins, designs, functions, support infrastructures, organizational affiliations, management philosophies, and requirements baselines. Planned systems represent a major initiative to achieve a more coherent functionality and to redress capability shortfalls. However, numerous factors present themselves that, in the future, may require multiple intelligence (Multi-NT) and multiple function (Multi-function) capable architectures to satisfy the needs of national users and operational commanders.

Developing the rationale, system attributes, and requirements for a Future Space Intelligence Architecture (FSIA) and determining the correct mix of reconnaissance, surveillance, and intelligence systems that satisfy national and military requirements is the objective of this thesis.



## 1997 THESIS ABSTRACTS

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### **A STUDY OF VIDEO TELECONFERENCING TRAFFIC ON A TCP/IP NETWORK**

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**Advisor: Murali Tummala, Department of Electrical and Computer Engineering**

**Second Reader: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering**

In this thesis the nature of variable bit rate (VBR) traffic, as generated by a video teleconferencing (VTC) application, in an Ethernet environment is studied. Analysis of the data retrieved from a testbed using metrics such as the rescaled adjusted range statistic, variance-time curve, and index of dispersion for counts illustrate the self-similar nature of traffic generated by a video teleconferencing application. This information is useful in formulating accurate models to support the various classes of traffic that will dominate the broadband ISDN (B-ISDN or ATM) infrastructure and in developing adequate access control mechanisms for these classes of traffic. The future of wide-area networking will see Ethernet LANs populating the access points of ATM WANs, thus making use of the ATM transport mechanism for wide-area communications. This thesis reports on work pertaining only to the traffic offered by the Ethernet LAN.

Java and the Simple Network Management Protocol (SNMP) provide the means with which to construct tools for gathering and simulating VTC traffic. Java applets were written to measure and simulate VTC traffic.

### **ACOUSTIC MOTION ESTIMATION AND CONTROL FOR AUTONOMOUS UNDERWATER VEHICLES**

**Hakki Çelebioglu-Lieutenant Junior Grade, Turkish Navy**

**B.S., Turkish Naval Academy, 1991**

**Master of Science in Electrical Engineering-June 1997**

**Advisor: Roberto Cristi, Department of Electrical and Computer Engineering**

**Second Reader: Xiaoping Yun, Department of Electrical and Computer Engineering**

An integrated model of acoustic motion estimation and control is presented. The control system is designed on the basis of the definitions of suitable Lyapunov functions for the different maneuvers in approaching a target. These functions allow the navigation and maneuvering tasks to be performed in a two-layered hierarchical architecture for closed-loop control. The motion estimation algorithm uses pencil beam profiling sonar range and bearing information. The operating environment is modeled with a suitable three-dimensional potential function and its gradient which forms an attractive field. This algorithm provides satisfactory performance for autonomous navigation and obstacle avoidance.

The applicability and robustness of this model are demonstrated with both actual test data obtained with the NPS *Phoenix* submersible and computer generated simulation data. The results show the effectiveness of the combined estimation and control model.

### **INTERACTIVE TOOLS FOR SOUND SIGNAL ANALYSIS/SYNTHESIS BASED ON A SINUSOIDAL REPRESENTATION**

**Ming-Fei Chuang-Lieutenant, Republic of China Navy**

**B.S., Chung-Chang Institute of Technology, 1992**

**Master of Science in Engineering Acoustics-March 1997**

**Advisor: Charles W. Therrien, Department of Electrical and Computer Engineering**

**Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering**

This thesis develops a series of programs that implement the sinusoidal representation model for speech and sound waveform analysis and synthesis. This sinusoidal representation model can also be used for a variety of sound signal transformations such as time-scale modification and frequency scaling. The above sound analysis/synthesis sinusoidal representations and transformations were developed as two interactive tools with Graphical User Interface (GUI) using MATLAB. In addition, an interactive tool for signal frequency component editing based on the sinusoidal model is also presented in this thesis.

## 1997 THESIS ABSTRACTS

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### **A HIGH POWER MICROWAVE APPLICATION FOR INFORMATION OPERATIONS (U)**

**Kurt Steven Collom-Lieutenant Commander, United States Navy**

**B.S., United States Naval Academy, 1985**

**Aerospace Engineering, May 1985**

**Master of Science in Systems Engineering-September 1997**

**and**

**James Edward Craig-Captain, United States Army**

**B.S., Texas A&M University, 1986**

**Physics, December 1986**

**Master of Science in Systems Engineering-September 1997**

**Advisors: Captain J.R. Powell, Information Warfare Academic Group**

**M.A. Morgan, Department of Electrical and Computer Engineering**

(U) This thesis documents the requirement, concept, and validation process for the feasibility demonstration of a high power microwave application for Information Operations. Information Warfare (IW) and Information Operations (IO) are about providing the commander or decision-maker with options. Information Attack provides new courses-of-action for the commander when pursuing his mission objectives and gives him unique capabilities to attack the adversary in previously unimaginable ways. In order to procure any new weapons system, there must be a valid requirement for the system. In some cases, if the technology already exists, or if the system under consideration is an extension of an existing requirement, the new system concept may be validated by a feasibility demonstration. Supporting documents to this thesis provide summaries of testing conducted to demonstrate and quantify the potential effectiveness of the application.

### **PROPAGATION OF VERTICALLY POLARIZED WAVES OVER ROUGH OCEAN SURFACES**

**Jeffrey G. Conrad-Lieutenant Commander, Canadian Navy,**

**B.S., Dalhousie University, 1985**

**Master of Science in Electrical Engineering-June 1997**

**Advisor: Ramakrishna Janaswamy, Department of Electrical and Computer Engineering**

**Second Reader: David C. Jenn, Department of Electrical and Computer Engineering**

The problem of propagation of vertically polarized radiowaves in an inhomogeneous atmosphere and over rough ocean surfaces is solved using the parabolic equation method. The solution of the parabolic equation is accomplished through the use of the Fourier split-step algorithm. Formulation of the equations is based upon (i) recognizing that the Fourier kernels of the transform equations in the split step algorithm represent plane waves and (ii) compensating for the effects of rough ocean surfaces by using a rough surface reduction factor directly in the spectral domain. To accomplish this a redefinition of the Fourier transform pair is done to ensure mathematical consistency. The formulation also incorporates the first and second derivatives of the refractivity index to accommodate steep gradients in the refractivity profile. Hanning windows are used in both the spatial and wavenumber domains to contain computational requirements. The effects on propagation by varying parameters such as wave heights, computational domain ceilings, frequency, and step size are investigated.

### **PROPAGATION OF VERTICALLY POLARIZED WAVES OVER ROUGH OCEAN SURFACES**

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## 1997 THESIS ABSTRACTS

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use of the Fourier split-step algorithm. Formulation of the equations is based upon (i) recognizing that the Fourier kernels of the transform equations in the split step algorithm represent plane waves and (ii) compensating for the effects of rough ocean surfaces by using a rough surface reduction factor directly in the spectral domain. To accomplish this a redefinition of the Fourier transform pair is done to ensure mathematical consistency. The formulation also incorporates the first and second derivatives of the refractivity index to accommodate steep gradients in the refractivity profile. Hanning windows are used in both the spatial and wavenumber domains to contain computational requirements. The effects on propagation by varying parameters such as wave heights, computational domain ceilings, frequency, and step size are investigated.

### **DATABASE ACCESS FROM THE WEB**

**A.S. Dean-Lieutenant Commander, United States Navy**

**B.B.A., University of Texas, 1982**

**Master of Science in Computer Science-March 1997**

**Advisors: C. Thomas Wu, Department of Computer Science**

**Monique P. Fargues, Department of Electrical and Computer Engineering**

Determining the best method for granting World Wide Web (Web) users access to remote relational databases is difficult. Choosing the best supporting Web/database link method for implementation requires an in-depth understanding of the methods available and the relationship between the link designer's goals and the underlying issues of Performance and Functionality, Cost, Development Time and Ease, Serviceability, Flexibility and Openness, Security, State, and Session.

This thesis examined existing methods for enabling Web-client access to remote relational databases and found that most fall within the general categories of Common Gateway Interface scripts, Server Application Programming Interfaces, Web-enabled Database Management Systems exporting query results in Hypertext Markup language, and independent client-based processes such as Java applets. To determine the best database access category we compared each one to the underlying link issues and conducted a case study for the IEEE Signal Processing Society.

The results of this thesis are: (1) a taxonomy of existing Web/database linking methods, (2) a thorough listing and examination of the underlying issues as they relate to each link method, and (3) recommendation and specification of the proper link method and hardware/software support system for the case study linkage problem.

### **IMPROVING DIGITAL SIGNAL PROCESSING CAPABILITIES OF THE AN/SRS-1 (V) SIGNAL DETECTION AND DIRECTION FINDING SET (U)**

**Bruce A. Dickey-Lieutenant, United States Navy**

**B.S. Civil Engineering, North Carolina State University, 1989**

**Master of Science in Electrical Engineering-June 1997**

**Advisors: Vicente C. Garcia Jr., National Security Agency Cryptologic Chair**

**Chiang Tom, Space and Naval Warfare Systems Center-San Diego**

### **CLASSIFIED ABSTRACT**

### **PREDISTORTION OF QUADRATURE AMPLITUDE MODULATION SIGNALS USING VOLTERRA SERIES APPROXIMATION**

**Michael T. Donovan-Major, United States Army**

**B.S., Purdue University, 1984**

**Master of Science in Electrical Engineering-December 1996**

**Advisor: Murali Tumala, Department of Electrical and Computer Engineering**

**Second Reader: Charles W. Therrien, Department of Electrical and Computer Engineering**

Modern digital communication systems are being called upon to move ever increasing amounts of information over decreasingly available bandwidth. This requires that communication systems employ bandwidth-efficient modulation schemes

## 1997 THESIS ABSTRACTS

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to conserve bandwidth while moving the information at higher data rates. A major stumbling block to using higher order modulation schemes in long-haul communication is the distortion caused by high power amplifiers. These high power amplifiers are required to amplify the signal power to a level that will allow distant receivers to correctly demodulate and decode the information. The distortion caused by the high power amplifiers can render a modulation scheme unusable due to the high symbol error rates which result from the extensive skewing of the modulation scheme's signal constellation. This thesis details a predistortion technique using Volterra series approximation techniques to model the inverse of the high power amplifier's distortion characteristics. A 64 Quadrature Amplitude Modulation (64-QAM) system incorporating a predistorter is used to demonstrate the ability to achieve acceptable bit error rates. The implementation of the inverse model and the communication system is performed in MATLAB. The results show the viability of predistortion of digital data to allow the higher order modulation schemes to be incorporated into communication schemes, increasing the overall data rate while conserving bandwidth.

### **TRACKING MULTIPLE TARGETS IN CLUTTERED ENVIRONMENTS WITH THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING FILTER**

**Darin T. Dunham-Captain, United States Marine Corps**

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**Advisor: Robert G. Hutchins, Department of Electrical and Computer Engineering**

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Tracking multiple targets in a cluttered environment is extremely difficult. Traditional approaches generally use simple techniques that combine gating with some form of nearest neighbor association to reduce the effects of clutter. When clutter densities increase, these traditional algorithms fail to perform well. To counter this problem, the multi-hypothesis tracking (MHT) algorithm was developed. This approach enumerates almost every conceivable combination of measurements to determine the most likely tracks. This process quickly becomes very complex and requires vast amounts of memory in order to store all of the possible tracks.

To avoid this complexity, more sophisticated single hypothesis data association techniques have been developed, such as the probabilistic data association filter (PDAF). These algorithms have enjoyed some success, but do not take advantage of future data to help clarify ambiguous situations.

On the other hand, the probabilistic multi-hypothesis tracking (PMHT) algorithm, proposed by Streit and Luginbuhl in 1995, attempts to use the best aspects of the MHT and the PDAF. In the PMHT, data is processed in batches, thereby using information from before and after each measurement to determine the likelihood of each measurement-to-track association. Furthermore, like the PDAF, it does not attempt to make hard assignments or enumerate all possible combinations, but instead associates each measurement with each track based upon its probability of association.

Actual performance and initialization of the PMHT algorithm in the presence of significant clutter has not been adequately researched. This study focuses on the performance of the PMHT algorithm in dense clutter and the initialization thereof. In addition, the effectiveness of measurement attribute data is analyzed, especially as it relates to algorithm initialization. Further, it compares the performance of this algorithm to the nearest neighbor, MHT, and PDAF.

### **DESIGN AND SIMULATION OF A LOW TEMPERATURE GaAs MESFET**

**Douglas C. Eskins-Lieutenant, United States Navy**

**B.S.E.E, University of Illinois, 1990**

**Master of Science in Electrical Engineering-June 1997**

**Advisor: Todd Weatherford, Department of Electrical and Computer Engineering**

**Second Reader: Ron Pieper, Department of Electrical and Computer Engineering**

With the need for fast, low power, radiation hardened electronics growing, especially in space based systems, GaAs has become an increasingly important technology. The Metal Semiconductor Field Effect Transistor (MESFET) is one of the most commonly used elements in GaAs Systems, and accurate modeling of its properties is essential to development of GaAs technology. The problem addressed is how to predict MESFET parameters based upon semiconductor-level proper-

## 1997 THESIS ABSTRACTS

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ties such as doping levels and junction placement. This thesis develops a semiconductor level model of a MESFET and uses it to evaluate various MESFET designs. Specifically, the Vitesse standard MESFET will be simulated and comparisons made with designs involving uniform P layers and Low Temperature (LT) grown GaAs layers. Such designs are thought to provide desirable properties with regard to radiation tolerance, especially single event upsets (SEU's). Computer simulations are run using both MATLAB and SILVACO software and compared against measured device parameters. Overall modeling suggests ways that the standard Vitesse MESFET process could be modified to incorporate these design changes, yet maintain standard device threshold voltage and current parameters. Furthermore, the design methodologies developed could be applied to a wider class of GaAs devices and aid in the overall development of this increasingly important technology.

### **AN ANALYSIS OF THE IIR AND FIR WIENER FILTERS WITH APPLICATIONS TO UNDERWATER ACOUSTICS**

**Natanael Ruiz Fontes-Lieutenant Commander, Brazilian Navy  
B.S., University of Sao Paulo, 1988**

**Master of Science in Electrical Engineering-June 1997**

**Master of Science in Engineering Acoustics-June 1997**

**Advisor: Charles W. Therrien, Department of Electrical and Computer Engineering**

**Second Reader: Anthony A. Atchley, Department of Physics**

A detailed analysis of the performance the Wiener optimal filter for estimating a signal in additive noise is carried out. A first order AR model is assumed for both the signal and noise. Both IIR and FIR forms of the filter are considered and expressions are derived for the processing gain, mean-square error, and signal distortion. These measures are plotted as a function of the model parameters. This analysis motivates a generalized form of the Wiener filter, which can improve the signal distortion. An analysis of this more general filter is then carried out. A practical noise removal algorithm based on short-time filtering using the generalized filter is also described and results of applying the algorithm to some typical underwater acoustic data are presented.

### **A 3-CHANNEL 14-BIT OPTIMUM SYMMETRICAL NUMBER SYSTEM (SNS) WIDEBAND DIGITAL ANTENNA: ANALYSIS OF THE ELECTRO-OPTIC SAMPLING FRONT END**

**Kevin D. Foster-Lieutenant, United States Navy  
BET, State University College at Buffalo, 1986**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering**

**Second Reader: John P. Powers, Department of Electrical and Computer Engineering**

Space considerations onboard naval surface ships frequently preclude adequate separation between high frequency (HF) transmit antennas and HF receive only antennas. As a result, high power shipboard emanations (for example, Link-11) interfere with low power signals of interest operating within the same frequency band. Symmetrical-Number-System (SNS) digital antennas provide high-resolution direct digitization of wideband signals with excellent in-band signal-rejection characteristics, which makes them ideal for operating within high RF environments. This thesis describes the design, construction, testing, and analysis of the optical electronics at the front end of a prototype optimum SNS digital antenna with a desired accuracy of 14 bits and a bandwidth of 2.5 MHz. The digital antenna utilizes pulsed laser sampling in conjunction with a parallel configuration of Mach-Zehnder interferometers which provide superior bandwidth and isolation performance over electronic sampling mechanisms. The interferometer folded output signal is in accordance with the optimum SNS which yields the maximum amount of information from a folding waveform. The theory and experimental performance of the optical subsystem and the analog electronics subsystem is presented, and the total system performance is evaluated. A summary of results and a conclusion with recommendations for improvements to follow-on systems is also discussed.

## 1997 THESIS ABSTRACTS

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### **DESIGN OF AN ALGORITHM FOR MINIMIZING LORAN-C TIME DIFFERENCE ERROR**

**Frederick M. France, Jr.-Lieutenant, United States Navy**

**B.S.E.E., University of Southern California, 1987**

**Master of Science in Electrical Engineering-September 1997**

**Electrical Engineer-September 1997**

**Advisors: Murali Tummala, Department of Electrical and Computer Engineering**

**Roberto Cristi, Department of Electrical and Computer Engineering**

The United States Coast Guard (USCG) is in the process of upgrading the hardware of the Loran-C Radionavigation System Control System. As part of this effort, the Computer-Assisted Loran-C Controller (CALOC), is also in need of improvement. CALOC performs four tasks: abnormality detection, time difference control, recordkeeping, and blink control. The work reported in this thesis focuses on time difference control. In many instances, CALOC does not accurately control the time difference error (TDE) within the established USCG control procedures. Two new algorithms are proposed here to control TDE more effectively: a proportional-integral-derivative (PID) controller and a Kalman filter. Actual TDE data recorded at three different master stations covering five Loran-C chains is used to evaluate the performance of the proposed controllers. The PID controller shows a substantial improvement in control compared to CALOC, and the Kalman filter exhibits even better performance, based on preliminary results. This improvement in control correlates directly with an increase in both predictable accuracy and repeatable accuracy.

### **COMPARISON OF THE STEP FREQUENCY RADAR WITH THE CONVENTIONAL CONSTANT FREQUENCY RADARS**

**Dimitrios N. Geladakis-Major, Hellenic Army**

**B.S., Hellenic Military Academy, 1980**

**B.S.E.E., National Polytechnic University of Athens, 1986**

**Master of Science in Electrical Engineering-December 1996**

**Advisor: Gurnam Gill, Department of Electrical and Computer Engineering**

**Second Reader: Phillip Pace, Department of Electrical and Computer Engineering**

In this thesis, the Step Frequency radar system is compared with the conventional Constant Frequency radar system. The two radar systems are separately analyzed and their analyses are followed by a comparison which is mainly based upon their effectiveness to detect moving targets in clutter. The step frequency waveform consists of a series of pulses whose pulse width is constant and whose carrier frequency is linearly increased from pulse to pulse in steps. As compared to the conventional constant frequency radar waveforms, the step frequency waveform can achieve high range resolution while still retaining the advantages of lower instantaneous receiver bandwidth and lower analog-to-digital sampling rate at the expense, however, of more complex signal processing.

### **DYNAMIC CONTROL OF A VEHICLE WITH TWO INDEPENDENT WHEELS**

**Douglas R. Gerrard-Lieutenant, United States Navy**

**B.S., University of Missouri, 1990**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering**

**Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering**

The feedback control and modeling of a mobile robot with two wheels that are independently steerable and drivable is studied. Two-wheel steer vehicles increase their maneuverability when both wheels are drivable and therefore increases their performance in confined spaces. A dynamic feedback control algorithm is developed, which enables the vehicle to move from any initial configuration (position and orientation) to any final configuration. Simulation results are presented to verify the independent control of the two position variables and the orientation variable. A comparison with a two-wheel steering and one wheel drive vehicle shows that driving both wheels increases performance and maneuverability.

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## 1997 THESIS ABSTRACTS

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### **IMPLEMENTING CLOSED-LOOP CONTROL ALGORITHMS FOR DC-TO-DC CONVERTERS AND ARCP INVERTERS USING THE UNIVERSAL CONTROLLER**

**Ronald J. Hanson-Lieutenant, United States Navy**

**B.S., University of North Dakota, 1988**

**Master of Science in Electrical Engineering-June 1997**

**Advisor: John G. Ciezki, Department of Electrical and Computer Engineering**

**Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering**

The objective of this thesis is to investigate the use of the Universal Controller to control the DC-to-DC power converter and the Auxiliary Resonant Commutated Pole (ARCP) power inverter. These power electronic devices are central to the development of a DC Zonal Electric Distribution System (DC ZEDS) that is scheduled for application in the twenty-first century surface combatant (SC-21). The development of appropriate closed-loop controls is a key element to this design process. The Universal Controller is a digital controller that was developed by personnel at the Naval Surface Warfare Center (NSWC), Annapolis, Maryland. The basic operation and control of the DC-to-DC buck converter and the ARCP inverter are described, with emphasis placed on the advantages of DSP control. A complete investigation of the hardware that comprises the controller and how to program the controller to implement closed-loop control is undertaken.

Previous studies have developed control algorithms that have been tested through simulation and analog hardware. In this research endeavor these control algorithms, particularly the one relevant to the DC-to-DC converter, are implemented using the Universal Controller to validate operations. Finally, a flow path for implementing the closed-loop control of the ARCP unit is discussed and recommendations for improvements in future designs are outlined.

### **THE MACH-ZEHNDER COUPLER**

**Maryanne Paap Heinbaugh-Lieutenant, United States Navy**

**B.A., University of Washington, 1986**

**Master of Science in Electrical Engineering-March 1997**

**Advisors: John Powers, Department of Electrical and Computer Engineering**

**Tri Ha, Department of Electrical and Computer Engineering**

The Naval Postgraduate School (NPS) is currently researching the potential for and feasibility of an optical signal demultiplexer based on the Mach-Zehnder coupler. The coupler will be capable of discriminating between  $M$  different CSK signals employing  $M$  Hadamard codes. This thesis involves the examination of a single Mach-Zehnder coupler that operates at 100 Mbps and specifically addresses the mathematical analysis of how it operates, the physical components necessary to build and test a Mach-Zehnder coupler, and the performance of the Mach-Zehnder coupler.

### **IMPLEMENTATION OF NARROWBAND SOUND PRESSURE LEVEL ESTIMATION ALGORITHM IN A PERSONAL COMPUTER ENVIRONMENT**

**Eric R. Horning-Lieutenant, United States Navy,**

**B.S., Cornell University, 1990**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Murali Tummala, Department of Electrical and Computer Engineering**

**Second Reader: Michael Shields, Department of Electrical and Computer Engineering**

This thesis implements the narrowband sound pressure level (SPL) estimation algorithm of the Automated Quick Look (AQL) system in a personal computer environment. The reengineered algorithm will act as a module of the proposed Beartrap Post-Mission Processing System (BPMPS). This new integrated system is designed to replace the current array of diverse processing systems that collectively serve as the post mission analysis system for Beartrap missions. Windows 95 is used as the operating environment and Microsoft Visual C++ as the implementation language. Capitalizing on the features of the chosen operating environment, this program provides the operator with the ability to analyze data from multiple sonobuoys and tonals associated with a submarine. The algorithm is tested using synthetic data based on two typical

## 1997 THESIS ABSTRACTS

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scenarios. From the results obtained in this thesis, it can be said that the algorithm performs correctly, and the operator is provided with a flexible, user friendly analysis tool.

### **SYSTEM CONTROLLER HARDWARE AND EMBEDDED SOFTWARE FOR THE PETITE AMATEUR NAVY SATELLITE (PANSAT)**

**James Anthony Horning-Civilian**

**B.S.C.S., California Polytechnic - San Luis Obispo, 1989**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Rudolf Panholzer, Space Systems Academic Group**

**Second Reader: Randy L. Wight, Department of Electrical and Computer Engineering**

This thesis documents the design of the hardware and embedded software of a digital computer that provides autonomous control of the PANSAT spacecraft. The system was designed for use during a two-year mission in a low earth orbit. The computer uses an Intel M80C186XL running at 7.3728 MHz, 512 kbytes of error-detection and correction RAM, 64 kbytes of ROM, and standard CMOS components to provide a general purpose microcomputer. The purpose of the computer is to control all subsystems of the spacecraft, perform analog-to-digital conversions, orchestrate duplicate hardware components to provide redundancy, and upload new software from a ground station. The hardware system was built on printed circuit boards which were manufactured by the Space System Academic Group of the Naval Postgraduate School and tested for proper operation. The embedded software was coded using 80186 Assembler and the C programming language, tested for proper operation, and placed into ROM as firmware.

### **THE APPLICATIONS IN MILITARY COMMUNICATIONS OF LOW AND MEDIUM EARTH ORBIT COMMERCIAL SATELLITE SYSTEMS**

**Ioannis Kakavas-Lieutenant, Hellenic Navy**

**B.Sc., Hellenic Naval Academy, 1989**

**Master of Science in Systems Engineering-September 1997**

**Advisors: Tri T. Ha, Department of Electrical and Computer Engineering**

**Vicente Garcia, National Security Agency Cryptologic Chair**

At the dawn of the 21<sup>st</sup> century several Low and Medium Earth Orbit Commercial Satellite constellations will be operational and they will be able to provide high bandwidth Global Communications in voice, data, and multimedia services for mobile consumers and also "users in the move." This research evolves as a continuation of previous studies (on Iridium, Globalstar, Teledesic, and Odyssey) and considers the ICO as well as the Teledesic and Global Broadcasting Services (GBS) systems in an effort to provide comprehensive model architecture. This model is desired to accommodate the narrowband, wideband, and broadcast requirements, respectively, of the U.S. MILSATCOM in addition to the communication needs of a model UN peacekeeping mission. The application of these systems to U.S. MILSATCOM coincides perfectly with the U.S. defense doctrine of a CONUS-based military with the capability of rapid global power projection to respond to crises throughout the global arena. Instead of investing heavily in new satellite systems, the U.S. military services can use the forthcoming commercial Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) systems to meet the information requirements of tactical commanders.



## 1997 THESIS ABSTRACTS

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### **THE USE OF NON-PARAMETRIC TRANSFER FUNCTION ESTIMATES TO PREDICT SUBMARINE HULL VIBRATIONS FROM NOISE SOURCE MEASUREMENTS (U)**

**Daphne Kapolka-Lieutenant Commander, United States Navy**

**B.A., University of Rhode Island, 1974**

**M.A., University of Chicago, 1976**

**M.S., Naval Postgraduate School, 1992**

**Doctor of Philosophy in Applied Physics-June 1997**

**Dissertation Chairman: Anthony A. Atchley, Department of Physics**

**Dissertation Supervisor: Robert M. Keolian, Department of Physics**

**Committee Members: Thomas J. Hofler, Department of Physics**

**Andrés Larraza, Department of Physics**

**Roberto Cristi, Department of Electrical and Computer Engineering**

**Joshua H. Gordis, Department of Mechanical Engineering**

Fundamental and practical limitations in the ability of non-parametric transfer function estimates to predict submarine hull vibrations are investigated. In order to assess the prediction performance and to succeed with non-stationary transfer functions, new methods and terminology are developed. An expression is derived for the maximum fractional error due to leakage which can be expected for the prediction of a pure sinusoid. For the data analysis, Bendat and Piersol's techniques for multiple-correlated inputs are used to condition up to eight input signals. Data is analyzed in three stages of complexity. The first data analyzed is from a scale model submarine driven by shakers. The next data is from the *USS Dolphin*, a deep-diving diesel-electric submarine. Measurements were taken on the Dolphin both surfaced running on diesels and submerged running on battery. During the submerged runs a minimal engineering line-up was used to limit the number of active noise sources. The final data analyzed was obtained from the *USS Hartford*, a nuclear attack submarine while in a normal engineering line-up. Results discussed include the percentage of power remaining in the processed hull signals, the lack of sensitivity of the predictions to input order, and the practical limitations encountered.

### **A DIRECT SEQUENCE-CODE DIVISION MULTIPLE ACCESS/ DIFFERENTIAL PHASE-SHIFT KEYING (DS-CDMA/DPSK) MODEM DESIGN**

**Önder Kara-Lieutenant Junior Grade, Turkish Navy**

**B.S., Turkish Naval Academy, 1991**

**Master of Science in Electrical Engineering-March 1997**

**Advisors: Tri Ha, Department of Electrical and Computer Engineering**

**R. Clark Robertson, Department of Electrical and Computer Engineering**

The development of a differential phase-shift keying (DPSK), direct sequence, spread spectrum modem is conducted for the purpose of creating a prototype design to be implemented in a multi-user environment. In this design, a maximal length sequence of 31 chips is used to spread the information data. The multi-user performance analysis is performed by using the Bit Error Rate (BER) test equipment (1645 Hewlett Packard data error analyzer). A multi-user interference cancellation circuit for two users is introduced, and measurements are performed to show its effectiveness.

The design itself encompasses the selection of components and demonstrates that the preliminary operational characteristics of a spread spectrum DPSK modem scheme for CDMA application can be achieved.

## 1997 THESIS ABSTRACTS

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### **ELECTRONIC COUNTER-COUNTER MEASURES POTENTIAL OF A NONCOHERENT FH/MFSK COMMUNICATIONS SYSTEM UNDER CONDITIONS OF WORST CASE HOSTILE ELECTRONIC COUNTER MEASURES AND FADING CHANNELS**

**George Katsoulis-Lieutenant Junior Grade Hellenic Navy**

**B.S., Hellenic Naval Academy, 1989**

**Master of Science in Electrical Engineering-March 1997**

**Advisor: R. Clark Robertson, Department of Electrical and Computer Engineering**

**Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering**

This thesis investigates the performance degradation resulting from multitone interference of orthogonal, noncoherent frequency-hopped, M-ary frequency-shift keyed receivers (FH/MFSK) where the effect of thermal and other wideband noise is not neglected. The multiple, equal power jamming tones are assumed to correspond to some or all of the possible FH M-ary orthogonal signaling tones. Furthermore, the channel is modeled as a Ricean fading channel, a possibility precluded when thermal noise is neglected; and both the signaling tones and the multiple interference tones are assumed to be affected by channel fading. Both band and independent band multitone interference are considered. Performance is evaluated by obtaining a union bound on the probability of bit error, and receiver performance is compared with exact results for band multitone interference of a noncoherent FH/MFSK receiver under comparable circumstances. Except for the case of Rayleigh fading of the signal, the union bound is very tight for those cases that can be compared with exact results. The advantages of the union bound approach are twofold. First, the union bound approach yields a solution that is far more less computationally intensive than that obtained with the exact approach. Second, the union bound approach allows numerical results to be obtained for interference conditions that are not amenable to exact analysis, such as independent multitone interference of FH/MFSK.

### **WAVELET ANALYSIS OF INSTANTANEOUS CORRELATIONS WITH APPLICATION TO FREQUENCY HOPPED SIGNALS**

**Nabil Hamdy Shaker Khalil-Colonel, Egyptian Army**

**BSEE., Military Technical College, Cairo, Egypt, 1978**

**MSEE., Am-Shams University, Cairo, Egypt, 1991**

**Doctor of Philosophy in Electrical Engineering-September 1997**

**Advisors: Ralph Hippenstiel, Department of Electrical and Computer Engineering**

**Monique Fargues, Department of Electrical and Computer Engineering**

Frequency hopped signals are widely used in various communication applications for their inherent security features. The demand, by civilian and governmental agencies, to intercept communication signals is increasing. The interception task can be summarized by detecting the signal's presence in additive noise, classifying the modulation type, estimating the control parameters, decoding the data, and decrypting the information content. This work addresses the merging of wavelet and correlation concepts to detect, classify, and estimate the parameters of frequency hopped signals. We address the interception problem in two ways. The first approach is based on a visual inspection of the wavelet surfaces generated from the instantaneous correlation function of the communication signal and leads to hop start/stop times estimates. In the second approach, we apply an energy-based processing scheme to estimate the hop start and stop times, the hop-scale pattern, and the hop frequency. Results show that frequency hopped signals can be identified at an SNR of 3 dB or 6 dB using visual inspection or an automated scheme, respectively.

## 1997 THESIS ABSTRACTS

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### **A STUDY OF NATIONAL RECONNAISSANCE OFFICE'S (NRO) FUTURE COMMUNICATIONS ARCHITECTURE (U)**

**Won H. Kim-Lieutenant, United States Navy  
B.S., University of Texas at Austin, 1986**

**Master of Sciences in Systems Technology-June 1997**

**Advisor: Dan C. Boger, Command, Control, and Communications Academic Group**

**William E. Clifton, Department of Electrical and Computer Engineering**

The National Reconnaissance Office (NRO) has identified much higher data rate requirements for future national systems. The goal of this thesis is to provide a possible alternate solution that would utilize crosslink technology developed for the Iridium Mobile Satellite System combined with existing and emerging laser communications technology. In addition to many other advantages over RF communications, laser communications can fulfill the extremely high data requirements of the future NRO systems. This technology could be a part of a new satellite constellation that can provide single and double global coverage in Stage I and Stage II, respectfully, of the satellite constellation design.

### **UTILIZING WEB-BASED TECHNOLOGY TO DESIGN AND IMPLEMENT A CONFERENCE INFORMATION SYSTEM**

**Todd M. Kinney-Lieutenant Commander, United States Navy  
B.A., Wabash College, 1986**

**Master of Science in Information Technology Management-September 1997**

**Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering**

**Second Reader: Rex A. Buddenberg, Department of Systems Management**

This thesis is a follow-on effort to work conducted by Michael Chalfant and Kevin Coats. The focus is the design and implementation of a web-based information system for the Asilomar Conference on Signals, Systems and Computers. This technical conference specializes in signal and image processing, communications, sensor systems, and computer hardware and software. Organized in collaboration with the Naval Postgraduate School, San Jose State University, and the IEEE Signal Processing Society, the Conference is conducted annually at the Asilomar Conference Facility in Pacific Grove, California. Initial project efforts concentrated on article submissions and system administration (i.e., database management). The article review process and overall implementation of the improved system is the focus of this thesis.

The objectives of this thesis are to: 1) analyze the article review process of the Asilomar Conference, 2) implement a World Wide Web (WWW) based article review process, and 3) implement the improved Asilomar Conference information system. Internet automation is accomplished via interactive WWW pages, created using Borland's Delphi as a programming tool, O'Reilly's WebSite as the web server, and Common Gateway Interface scripts as the mechanism for interactivity. This interactivity provides seamless global access to the Conference database and processes.

### **A DIRECT SEQUENCE-CODE DIVISION MULTIPLE ACCESS/ BINARY PHASE SHIFT KEYING (DS-CDMA/BPSK) MODEM DESIGN**

**Murat Kocakanat-Lieutenant Junior Grade, Turkish Navy  
B.S., Turkish Naval Academy, 1991**

**Master of Science in Electrical Engineering-March 1997**

**Advisor: Tri Ha, Department of Electrical and Computer Engineering**

**R. Clark Robertson, Department of Electrical and Computer Engineering**

In this thesis, the design of a direct sequence - code division multiple access/binary phase-shift keying (DS-CDMA/BPSK) modem is examined. In this prototype modem design, a short maximal length sequence of 31 chips is used to spread the information data. The design can be extended to longer codes to provide greater capacity and processing gain.

The hardware used in the functional realization of a working design is also discussed, and the preliminary operational characteristics of a spread spectrum BPSK modem are achieved. The multi-user performance analysis is conducted using

## 1997 THESIS ABSTRACTS

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Bit Error Rate (BER) test equipment (HP1645A). The development of the final version of the modem operating at radio frequency (RF) is not conducted, but proof of concept is provided.

### **THE DESIGN OF THE RADIO FREQUENCY (RF) SUBSYSTEM PRINTED CIRCUIT BOARDS FOR THE PETITE AMATEUR NAVY SATELLITE (PANSAT)**

**Carl Andrew Lahti-Lieutenant, United States NaRy**

**B.S.S.E., United States Naval Academy, 1989**

**Master of Science in Electrical Engineering-June 1997**

**Electrical Engineer-June 1997**

**Advisors: Randy Borchardt, Department of Electrical and Computer Engineering**

**Rudolf Panholzer, Space Systems Academic Group**

The Petite Amateur Navy Satellite (PANSAT) is a small digital communication satellite being developed by the Space Systems Academic Group and the Naval Postgraduate School. This thesis describes the layout of the three final flight printed circuit boards for the radio frequency (RF) subsystem for PANSAT. The circuits and layouts are documented in detail. A link analysis is performed to verify system design and a power budget provided for integration with other satellite systems. Printed circuit board design fundamentals and high frequency printed circuit board construction techniques are also described.

### **EVALUATION OF LAYOUT TECHNIQUES FOR RADIATION TOLERANT BULK CMOS INTEGRATED CIRCUITS**

**Andrew S. Lambley-Lieutenant, United States Navy**

**B.S., Auburn University, 1989**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering**

**Second Reader: Todd Weatherford, Department of Electrical and Computer Engineering**

Over the past seven years, the number of U.S. companies producing radiation-hardened (rad-hard) devices has dropped by 80%. National security dictates that we must maintain a domestic ability to produce rad-hard devices for use in space-borne and strategic systems. This research evaluates Integrated Circuit (IC) layout techniques for bulk CMOS processes that attempt to compensate for the effects of long-term exposure of the semiconductor devices to ionizing radiation. If successful, radiation-tolerant components could be manufactured without special fabrication equipment or costly circuit redesign. In addition to ensuring a domestic space-worthy electronics manufacturing capability, the utilization of standard fabrication processes could make the cost of producing rad-tolerant parts dramatically lower.

### **THE ANALYSIS OF INTERCONNECTED, HIGH-POWER DC-DC CONVERTERS FOR DC ZONAL ELECTRICAL DISTRIBUTION**

**Thomas Lucian Langlois-Captain, United States Marine Corps**

**B.S., University of Texas at Austin, 1987**

**Master of Science in Electrical Engineering-June 1997**

**Advisor: J. G. Ciezki, Department of Electrical and Computer Engineering**

**Second Reader: R. W. Ashton, Department of Electrical and Computer Engineering**

As the United States Navy progresses into the twenty-first century, new concepts in shipboard electrical power management are being explored. One area of significant interest to the Navy is utilization of a DC Zonal Electrical Distribution System (DC-ZEDS) rather than a traditional AC distribution system. This system employs a network of solid-state power conversion devices to supply shipboard electrical loads from two or more high-voltage DC busses. The interconnection of these power converters stimulates several phenomenological questions and motivates multiple areas for study. Of key interest include interconnection dynamics through transmission lines and how the individual power sections of a DC-ZEDS

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## 1997 THESIS ABSTRACTS

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architecture react under real-world load stresses. The focus of this thesis is to use the Power Electronic Building Block Network Testbed at the Naval Postgraduate School to examine the effects of line inductance and step changes in load on interconnected DC-DC converters. The findings of this research effort indicate that a system of networked buck converters can successfully operate in a DC-ZEDS architecture. In particular, buck converters were found to operate stably and were found to have acceptable transient performance for a variety of load conditions and interconnection topologies.

### **SONAR-BASED LOCALIZATION OF MOBILE ROBOTS USING THE HOUGH TRANSFORM**

**Khine Latt-Civilian**

**B.S.Ch.E., Pennsylvania State University, 1983**

**Master of Science in Engineering Science-March 1997**

**Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering**

**Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering**

For an autonomous mobile robot to navigate in an unknown environment, it is essential to know the location of the robot on a real-time basis. Finding position and orientation of a mobile robot in a world coordinate system is a problem in localization. Dead-reckoning is commonly used for localization, but position and orientation errors from dead-reckoning tend to accumulate over time. The objective of this thesis is to develop a feature-based localization method that allows a mobile robot to re-calibrate its position and orientation by automatically selecting wall-like features in the environment.

In this thesis, the selection of features is accomplished by applying the Hough transform to sonar data. The Hough transform makes it possible to select the optimal feature (the longest wall, in this case) without finding all possible line segments from the sonar data. A least-square line fitting method is then employed to construct a model of the line segment that represents the feature selected by the Hough transform. The algorithm developed was tested using synthetic and real sonar data. Experimental results demonstrated the effectiveness of the proposed localization methods.

### **FIELD-SENSITIVE PHOTOCONDUCTIVE SAMPLING PROBE MEASUREMENTS OF A SINGLE EVENT UPSET**

**Ezra J. Ledbetter, Jr.-Lieutenant, United States Navy**

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**Master of Science in Electrical Engineering-June 1997**

**Advisors: Todd Weatherford, Department of Electrical and Computer Engineering**

**John F. Whitaker, Department of Electrical Engineering and Computer Science,  
University of Michigan**

This thesis describes the use of a field-sensitive photoconductive sampling probe to measure a Single Event Upset (SEU) induced by an ultra-short optical pulse. The main thrust of the study is to show that a photocurrent can be measured inside of an IC and time resolve the transient of an SEU. The results will be compared to simulation predictions, and new applications for use of the probe will be explored.

This experiment is the first time that an SEU pulse has been measured inside of an IC. The Field-Sensitive photoconductive sampling probe was developed at the Center for Ultrafast Optical Science at the University of Michigan. It is the only one of its kind. This setup is unique, in that it has the capability of making microvolt-sensitivity measurements inside of an IC without conductive contact, therefore, making it noninvasive. The probe is capable of measuring picosecond voltage waveforms through passivation layers without charge drainage.

## 1997 THESIS ABSTRACTS

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### **ELECTROMAGNETIC RESONANCES OF METALLIC BODIES**

**William Anthony Lintz-Lieutenant, United States Navy**

**B.E.E., Villanova University, 1992**

**Master of Science in Electrical Engineering-June 1997**

**Advisors: Richard W. Adler, Department of Electrical and Computer Engineering**

**Jovan E. Lebaric, Department of Electrical and Computer Engineering**

Every object has the ability to radiate and scatter electromagnetic waves. The ability to predict frequencies of maximum radiation or scattering has been limited to simple objects, such as dipoles, or objects with high degrees of symmetry. This thesis describes modifications that can be made to a computational electromagnetic technique, the Method of Moments, to allow for such predictions to be made for complex metallic objects. This new technique has been implemented as a MATLAB computer program and tested on objects with known resonance frequencies. Finally, the code's ability to handle large complex objects is demonstrated by investigating the resonance frequencies for a Cessna aircraft.

### **SHEPHERD ROTARY VEHICLE: MULTIVARIATE MOTION CONTROL AND PLANNING**

**Edward J. Mays-Major, United States Marine Corps**

**B.S., University of Florida, 1984**

**M.S., University of Southern California, 1994**

**Master of Science in Computer Science-September 1997**

**and**

**Ferdinand A. Reid-Lieutenant, United States Navy**

**B.B.A., Georgia State University, 1990**

**Master of Science in Computer Science-September 1997**

**Advisor: Yutaka Kanayama, Department of Computer Science**

**Second Reader: Xiaoping Yun, Department of Electrical and Computer Engineering**

Millions of acres of the U.S. formerly used defense sites (FUDS) are contaminated with unexploded ordnance (UXO) as a result of past military use. The process of returning the land to the civilian sector is sensitive, intensive, and costly (e.g., millions of dollars, and the loss of human life). Hence "clearing" (i.e., site remediation, range clearance, and explosive ordnance disposal) UXO's from FUDS is a complex problem. Existing clearing methods are inaccurate, dangerous, and labor intensive. This thesis shows that through robotics technology (e.g., "Shepherd" rotary vehicle with three degrees of freedom) and the use of advanced computer technology it is possible to make clearing tasks safer, more cost-effective, and more efficient. An over arching hardware and software architecture was developed for Shepherd (including a self-contained on-board computer system). The software system was developed for timer control, motion control, user interface, and an operating kernel. The hardware and software organization, structure, and interaction provide the framework for real-time control. This research included the use of encoders, digital boards, and a counter board and required the handling of interrupts, electric motor manipulation by servomotor controllers, and communication using RS232 and VMEbus technology. The kinematics algorithms and a real-time operating kernel were implemented using the C language. "Shepherd" research has laid the foundation for the flexible, robust, and precise motion needed for UXO clearing.

### **MARTES, A SIGNAL ANALYSIS TOOLKIT FOR THE FUTURE (U)**

**Edward C. McCarthy-Major, United States Marine Corps**

**B.S. Mathematics, United States Naval Academy, 1984**

**Master of Science in Electrical Engineering-December 1996**

**Advisors: Vicente C. Garcia Jr., National Security Agency Cryptologic Chair**

**Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering**

The ability of the United States to analyze electronic emissions and exploit them effectively is essential to our national defense. In the past two decades numerous digital signal process software programs have been developed by many agencies that attempt to process and exploit the vast number of available signals. This haphazard approach has led to a number of

## 1997 THESIS ABSTRACTS

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different agencies using a plethora of software programs to attack signals that are specific to their particular mission. This lack of standardization has led to many problems including information incompatibility, the need for file conversion, and constant need for operators to train on new tools. This thesis will examine the effectiveness of a government software package that attempts to provide a standardized all-purpose digital tool kit which can be added to and used by all government agencies. The thesis will begin by introducing the major features of the software and some of the signal analysis requirements of various agencies. It will then demonstrate the potency of the software by presenting a step-by-step analysis of numerous signals from various arenas. The thesis will then compare the results to some other currently used tools.

### **THE ANALYSIS, SIMULATION, AND CONTROL OF CYCLOCONVERTER DRIVES FOR SHIP PROPULSION**

**Christopher Paul Mercer-Lieutenant, United States Navy  
B. S., Maine Maritime Academy, 1988**

**Master of Science in Electrical Engineering-December 1996**

**Advisor: John G. Ciezki, Department of Electrical and Computer Engineering**

**Second Reader: Robert W. Ashton, Department of Electrical and Computer Engineering**

Naval expeditionary forces of the future will require new, technologically advanced, multi-mission surface combatants. The design philosophy for future surface combatants stresses survivability, efficiency, and modularity through the use of a modern open-architecture consisting of commercial-off-the-shelf and dual-use systems. An integrated propulsion and electrical power generation system which utilizes advanced, commercially viable power electronics and state-of-the-art control and monitoring systems is viewed as the appropriate system for the future surface combatant.

This study provides the designing naval engineer with technical background information and design considerations for the application of a cycloconverter drive for ship propulsion in an integrated power system. The cycloconverter is a power electronic circuit which performs a single-stage conversion of an AC input voltage at one frequency to an ac output voltage of variable frequency and amplitude. Cycloconverters are generally used for low-speed, very large horsepower applications and with suitable closed-loop control can develop torque and speed responses suitable for ship propulsion. External performance characteristics and control issues for the cycloconverter are discussed, followed by a time-domain computer simulation of an integrated ship propulsion drive utilizing a cycloconverter. From the technical background information, external performance characteristics and computer simulation analysis, the designing naval engineer can make educated decisions on the application of a cycloconverter drive for ship propulsion.

### **A COMPUTATIONALLY EFFICIENT AND COST EFFECTIVE MULTISENSOR DATA FUSION ALGORITHM FOR THE UNITED STATES COAST GUARD VESSEL TRAFFIC SERVICES SYSTEM**

**Sean A. Midwood-Lieutenant Commander, Canadian Armed Forces**

**B. Eng., Lakehead University, 1989**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Murali Tummala, Department of Electrical and Computer Engineering**

**Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering**

This thesis develops an algorithm to fuse redundant observations due to multiple sensor (type and location) coverage in order to provide a significant reduction in duplicate track information provided to Vessel Traffic Services (VTS) operator displays. The design of the algorithm allows acceptance of inputs from any type of sensor (radar, acoustic, GPS, system generated, and manual tracks) as long as the basic decision criteria elements are provided. The result of this effort is a computationally efficient and cost effective software solution to a significant system deficiency that impacts greatly on overall waterway safety. The algorithm is tested with real data collected from the VTS system at Puget Sound in September 1996. The results indicate that the algorithm correctly fuses redundant sensor observations on the same vessel resulting in a significant reduction in the amount of unnecessary information presented to the VTS operator.

## 1997 THESIS ABSTRACTS

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### **A MULTI-CHANNEL HIGH-SPEED FIBER-OPTIC DIGITAL DATA LINK**

**James Howard Mills-Lieutenant, United States Navy**

**B.A., University of Arizona, 1990**

**Master of Science in Electrical Engineering-December 1996**

**Advisor: John P. Powers, Department of Electrical and Computer Engineering**

**Second Reader: Ron J. Pieper, Department of Electrical and Computer Engineering**

This research presents the design, implementation, and testing of a multi-channel, high-speed fiber-optic data link. The aim of this study is to evaluate this data link for use as a viable and economical shipboard communication system. Incorporated in the design are commercial-off-the-shelf technology system (COTS) high-speed fiber-optic modules, standard single-mode optical fiber, and integrated circuits from two digital logic families-Emitter Coupled Logic (ECL) and Transistor-Transistor Logic (TTL). Time division multiplexing (TDM) techniques are used for transmission and reception of the 14-channel data link. The data link is a subsystem of the high-resolution digital antenna system.

### **OCEAN WAVE DATA ANALYSIS USING HILBERT TRANSFORM TECHNIQUES**

**Moisés M. Navarro-Lieutenant Commander, Venezuelan Navy**

**B.S., Venezuelan Naval School, 1982**

**Master of Science in Applied Physics-December 1996**

**Advisors: Andrés Larraza, Department of Physics**

**Roberto Cristi, Department of Electrical and Computer Engineering**

A novel technique to determine the phase velocity of long-wavelength shoaling waves is investigated. Operationally, the technique consists of three steps. First, using the Hilbert transform of a time series, the phase of the analytic signal is determined. Second, the correlations of the phases of analytic signals between two points in space are calculated and an average time of travel of the wave fronts is obtained. Third, if directional spectra are available or can be determined from time series of large array of buoys, the angular information can be used to determine the true time of travel. The phase velocity is obtained by dividing the distance between buoys by the correlation time. Using the Hilbert transform approach, there is no explicit assumption of the relation between frequency and wavenumber of waves in the wave field, indicating that it may be applicable to arbitrary wave fields, both linear and nonlinear. Limitations of the approach are discussed.

### **DESIGN, ANALYSIS, AND PROTOTYPE FOR ONE-CYCLE CONTROLLER**

**James R. Nelson-Lieutenant, United States Navy**

**B.S., Auburn University, 1989**

**Master of Science in Electrical Engineering-December 1996**

**Advisor: Robert W. Ashton, Department of Electrical and Computer Engineering**

**Second Reader: John G. Ciezki, Department of Electrical and Computer Engineering**

As the Navy progresses into the twenty-first century, new concepts in shipboard electrical power management are being explored. One area of significant interest to the Navy is utilization of DC electrical distribution systems rather than traditional AC distribution systems. The DC Zonal Electrical Distribution System is a prime candidate for direct application to modern power distribution. This system employs solid-state conversion devices to supply ships loads from one of two high-voltage DC busses. A new type of control technique known as One-Cycle Control has recently been proposed which may be of use in the control of these power converters. Specific advantages of this technique include no steady-state or dynamic error between the control signal and the controlled variable, robust performance, power source perturbation rejection, fast dynamic response to changes in the control signal, general switching applications, and automatic switching error correction. The focus of this thesis is to validate the One-Cycle Control theory through simulation and testing of a prototype controller.



## 1997 THESIS ABSTRACTS

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### **SUPPLEMENTING NATIONAL SYSTEM SUPPORT TO THE WARFIGHTER: SIGINT CAPABLE UNMANNED AERIAL VEHICLES (UAVS) (U)**

**Karla J. Nemec-Lieutenant, United States Navy**

**B.A., University of Missouri, Columbia, 1990**

**Master of Science in Space Systems Operations-September 1997**

**Advisors: Vicente Garcia, National Security Agency Cryptologic Chair**

**Professor Herschel Loomis, Department of Electrical and Computer Engineering**

Unmanned Aerial Vehicles (UAVs) represent a platform that could supplement future national system Signals Intelligence (SIGINT) support to the warfighter with the development of proper payloads and procedures, as explored in this thesis. Payload designs must ensure collection capability against the complex, dynamic communications and non-communications threats emerging worldwide. Multi-platform Time and Frequency Difference of Arrival (TDOA/FDOA) geolocation methodologies must complement payload single-platform direction finding capabilities to allow cooperative, precision target geolocation while maintaining independent platform operations capability. Standardized, all-source, automated processing tool kits must allow interoperability between collection platform processing facilities and automated processing whenever possible. To effect the interoperable collection, geolocation and processing capabilities and ensure rapid dissemination of valuable SIGINT information, a robust network of high data rate links must be established. The data links provide the connectivity necessary to accommodate specific cooperative UAV/national system activities envisioned by the author. These key activities include cooperative geolocation, cross-cueing, and data relay operations. In developing the UAV and cooperative UAV/national system SIGINT concepts discussed in this thesis, SIGINT planners provide the warfighter with sustained, improved SIGINT collection in areas and situations too dangerous for collection via other means.

### **OPTIMUM CODES FOR FAST FREQUENCY-HOPPED BINARY FREQUENCY-SHIFT KEYING RECEIVERS WITH SELF-NORMALIZATION COMBINING AND HARD DECISION DECODING IN FADING CHANNELS**

**Xenofon Nikolakopoulos-Lieutenant, Hellenic Navy**

**B.S.E.E, Hellenic Naval Academy, 1988**

**Master of Science in Electrical Engineering-March 1997**

**Advisors: Tri T. Ha, Department of Electrical and Computer Engineering**

**R. Clark Robertson, Department of Electrical and Computer Engineering**

The application of forward error correction coding to a fast frequency-hopped binary frequency-shift keying (FFH/BFSK) noncoherent receiver with self-normalization combining under broadband and partial-band jamming is discussed in this thesis.

The performance of the receiver is examined when data are encoded using Reed-Solomon codes, convolutional codes, and concatenated Reed-Solomon and convolutional codes, all with hard decision decoding. The effects of the transmission channel is considered and results are derived for a Rayleigh fading channel and Ricean fading channels with several different ratios of direct-to-diffuse signal power. Only frequency nonselective, slowly fading channels are considered.

The combination of diversity and forward error correction coding is found to improve the performance of the receiver in the presence of both broadband and partial-band jamming and optimum codes for each coding scheme are also discussed.

## 1997 THESIS ABSTRACTS

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### **VIDEO CONFERENCING USING PACKET RADIO TECHNOLOGY**

**Narongchai Nimitbunanant-Second Lieutenant, Royal Thai Air Force**

**B.S., U.S. Air Force Academy, 1995**

**Master of Science in Systems Engineering-June 1997**

**Advisor: Chin-Hwa Lee, Department of Electrical and Computer Engineering**

**Second Reader: Supachai Sirayanone, Department of Meteorology**

Information and its effective delivering means are becoming more and more important in today's world. Video-conferencing is a highly effective means to deliver information since it is interactive. This thesis studies the packet-radio-networking technology that can be used to support video-conferencing applications. The popular networking protocols, i.e., the Amateur X.25 (AX.25), the Transport Control Protocol/Internet Protocol (TCP/IP), and other protocols, widely used in packet radio technology are described. By using the File Transfer Protocol (FTP) of the TCP/IP standard, the average speed and time of various file sizes across a half-duplex radio channel, a full-duplex emulated-radio channel, and a RS-232 link were collected and analyzed. Finally, comparisons were made among channels, including the effects of an additional routing node.

### **ALTERNATIVE GATE DESIGNS FOR IMPROVED RADIATION HARDNESS IN BULK CMOS INTEGRATED CIRCUITS**

**Sidney Scott Noe-Lieutenant, United States Navy**

**B.S., Rochester Institute of Technology, 1989**

**Master of Science in Electrical Engineering-March 1997**

**Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering**

**Second Reader: Todd R. Weatherford, Department of Electrical and Computer Engineering**

In the last 30 years, the world has become increasingly dependent on space-based systems. These systems require varying degrees of radiation tolerance to perform their missions. Current radiation hardening processes for integrated circuits are expensive and consume significant layout area, increase power consumption, and decrease the frequency of operation. Furthermore, it is becoming more difficult to find fabricators for radiation-hardened electronic devices. In this thesis, two new transistor designs using a bulk CMOS process are tested for radiation hardness and are compared to a standard design. Both show a degree of improvement in subthreshold leakage current and threshold voltage shift over the control transistors. The new designs demonstrate an ability to reduce the effects of radiation on transistor parameters by means of an applied voltage to a second layer of polysilicon material above the control gate material.

### **THE OPERATION AND INTERACTION OF THE AUXILIARY RESONANT COMMUTATED POLE CONVERTER IN A SHIPBOARD DC POWER DISTRIBUTION NETWORK**

**Mark J. Oberley-Lieutenant, United States Navy**

**B.S., Colorado School of Mines, 1989**

**Master of Science in Electrical Engineering-December 1996**

**Advisor: John G. Ciezki, Department of Electrical and Computer Engineering**

**Second Reader: Robert W. Ashton, Department of Electrical and Computer Engineering**

The objective of this thesis is to investigate the use of the Auxiliary Resonant Commutated Pole Converter (ARCP) as a DC-to-AC power converter. The advantages and disadvantages of resonant converters over non-resonant, or hard-switched converters, are investigated. Basic ARCP circuit operation is modeled, with emphasis placed on examining the commutation between high and low voltage states. Detailed ARCP converter operation is modeled in software and compared to a software model of a hard-switched converter. Comparisons are made using total harmonic distortion calculations, to establish the reliability of using the hard-switched model to perform control synthesis for the ARCP.

Several control algorithms are tested through simulation and the results analyzed. The advantages of performing control in the synchronous vice stationary reference frame are shown. Testing on a reduced-scale circuit model using a digital signal processing system (dSPACE) to implement control algorithms is used to validate the control algorithm simulations.

## 1997 THESIS ABSTRACTS

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A new method of waveform modulation, Space Vector Control, is introduced and compared with conventional methods. Finally the operation of a prototype ARCP unit is discussed, and recommendations for improvements in future designs are presented.

### **THE VLSI IMPLEMENTATION OF A GaAs GIC SWITCHED CAPACITOR FILTER**

**Harry Garrett Oldland, III-United States Marine Corps**

**B.A., Pennsylvania State University, 1982**

**Master of Science in Electrical Engineering-June 1997**

**Advisor: Sherif N. Michael, Department of Electrical and Computing Engineering**

**Second Reader: Raymond F. Bernstein Jr., Department of Electrical and Computing Engineering**

Presented is the initial step for the eventual implementation of a programmable Generalized Immitance Converter (GIC) switched capacitor filter in a GaAs process. This thesis is the initial engineering effort in the accomplishment of this goal. The focus of this thesis is to design, fabricate, and test of all necessary components for the construction of a GIC switched capacitor filter. All components will be stand alone so that future testing of each component may be accomplished. VLSI implementation will be accomplished using the Magic Cad package and the Vitesse HGaAs3 fabrication process. The simulation of the components will be accomplished using HSpice.

### **DETECTION AND ESTIMATION OF FREQUENCY HOPPING SIGNALS USING WAVELET TRANSFORMS**

**Howard F. Overdyk-Captain, United States Marine Corps**

**B.S., Iowa State University, 1991**

**Master of Science in Electrical Engineering-September 1997**

**Advisors: Monique P. Fargues Department of Electrical and Computer Engineering**

**Ralph Hippenstiel, Department of Electrical and Computer Engineering**

This thesis investigates the use of wavelet transforms in the detection and estimation of spread spectrum frequency hopping signals. The technique developed in this work makes only two basic assumptions of a minimum hopping time and a minimum frequency hopping differential. The approach is based on the phase information of the temporal correlation function and the resulting discrete wavelet transform is used to estimate the hopping time of frequency hopping signals. Results show the proposed scheme is robust to additive white noise for SNR levels of 3 dB and above.

### **DESIGN AND PROTOTYPE DEVELOPMENT OF AN OPTIMUM SYMMETRICAL NUMBER SYSTEM DIRECTION FINDING ARRAY**

**Panayiotis Papandreou-Lieutenant Junior Grade, Hellenic Navy**

**B.S., Hellenic Naval Academy, 1989**

**Master of Science in Electrical Engineering-March 1997**

**Advisors: Phillip E. Pace, Department of Electrical and Computer Engineering**

**David C. Jenn, Department of Electrical and Computer Engineering**

One method of estimating the direction of an electromagnetic source is based on phase comparison. In this thesis the design and fabrication of a prototype antenna to demonstrate a new DF antenna architecture is described. Four antenna elements are grouped into three pairs with element spacing according to a set of symmetrical number system pairwise relatively prime moduli ( $m_1=3$ ,  $m_2=4$ ,  $m_3=5$ ). The phase difference between each pair of elements is a symmetrical folding waveform that is determined using a mixer. The output voltage from each pair is amplitude analyzed using a small comparator ladder. In each channel, the symmetrically folding waveform, folds in accordance with the channel modulus and thus, only requires a precision according to that modulus. A high resolution DF is achieved after the N different SNS moduli are used and the results of these low-precision channels are recombined to yield the direction of arrival. The frequency of operation of the prototype is 8.5 GHz. Results based on measured and simulated data are presented.

## 1997 THESIS ABSTRACTS

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### **SINGLE-EVENT ANALYSIS OF LT GaAs MESFET INTEGRATED CIRCUITS**

**Richard Anthony Radice-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1990**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Todd Weatherford, Department of Electrical and Computer Engineering**

**Second Reader: Douglas J. Fouts, Department of Electrical and Computer Engineering**

There is a growing need for the use of electronics in radiation environments such as space. Gallium arsenide (GaAs) semiconductor technology is highly desirable for these applications because it consumes less power at higher speeds than silicon (Si) and shows superior radiation hardness over silicon technologies except for Single-Event-Upset (SEU). This thesis examines GaAs MESFETs fabricated in the Vitesse H-GaAsIII® process utilized in Direct Coupled FET Logic (DCFL) inverters. These simulations are targeted at determining the vulnerability of these devices to SEU. MESFETs fabricated on low-temperature grown GaAs (LT GaAs) epitaxial layers are investigated in addition to the conventional MESFET process using only bulk GaAs. Two-dimensional computer simulations are performed to determine the most effective method to simulate SEU charge collection mechanisms and how effective the LT GaAs buffer layer is at reducing SEU vulnerability. This thesis is part of a larger project that is attempting to develop a new wafer design that can be inserted into the current Vitesse fabrication process to produce radiation-hardened circuits. Computer simulations are performed using MIXEDMODE®, which is a SPICE simulator for the ATLAS® device simulation software created by SILVACO International Inc.®

### **PCM INFRASTRUCTURE TECHNOLOGIES**

**Mark D. Randolph-Lieutenant, United States Navy**

**B.S., Rensselaer Polytechnic Institute, 1990**

**Master of Science in Electrical Engineering-December 1996**

**Advisors: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering**

**Vicente C. Garcia, Jr., National Security Agency Cryptologic Chair**

In today's modern communication environment high data rate synchronous and plesiochronous pulse coded modulations signals fill the air around us. This thesis looks at the formation of these modern communication "shell structures" and explores possible techniques for identifying underlying data structure signatures within the overall shell without decomposition of the outer structure. Simple Fourier Transform techniques are examined along with Cyclostationary processing techniques. This thesis accomplishes three tasks. First it forms an accurate and concise manual for understanding modern digital communications. Next this work provides a groundwork of traditional as well as contemporary techniques (such as cyclostationarity) for study of these signals. Finally, this thesis studies the effects on underlying periodicity and statistical periodicity as the signal shell is developed.

### **DESIGN, CONSTRUCTION, AND ANALYSIS OF A 14-BIT DIRECT DIGITAL ANTENNA UTILIZING OPTICAL SAMPLING AND OPTIMUM SNS ENCODING**

**William P. Ringer-Lieutenant, United States Navy**

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**Master of Science in Electrical Engineering-September 1997**

**Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering**

**Second Reader: John P. Powers, Department of Electrical and Computer Engineering**

Direct digital direction finding (DF) antennas will allow an incoming signal to be digitally encoded at the antenna with high dynamic range (14 bits 86 dB) without the use of down conversion that is typically necessary. As a shipboard DF device, it also allows for the encoding of wide-band, high-power signals (e.g.,  $\pm 43$  volts) that can often appear on shipboard antennas due to the presence of in-band transmitters that are located close by. This design utilizes three pulsed-laser driven Mach-Zehnder optical interferometers to sample the RF signal. Each channel requires only 6-bit accuracy (64 comparators) to produce an Optimum Symmetrical Number System (OSNS) residue representation of the input signal. These residues are

## 1997 THESIS ABSTRACTS

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then sent to a locally programmed Field Programmable Gate Array (FPGA) for decoding into a 14-bit digital representation of the input RE voltage. Modern day FPGA devices are rapidly becoming the state-of-the art in programmable logic. The inclusion of on-chip flip-flops allows for a fast and efficient pipelined approach to OSNS decoding. This thesis documents the first 14-bit digital antenna which utilizes an FPGA algorithm as a method of OSNS decoding. This design uses FPGA processors for both OSNS decoding and Parity processing.

### **A CODED ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING SIMULATION OF A HIGH DATA RATE, LINE-OF-SIGHT, DIGITAL RADIO FOR MOBILE MARITIME COMMUNICATIONS**

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**Electrical Engineer-June 1997**

**Advisor: Paul H. Moose, Department of Electrical and Computer Engineering**

**Second Reader: R. Clark Robertson, Department of Electrical and Computer Engineering**

The Naval Command, Control and Ocean Surveillance Center (NCCOSC), Research Development Evaluation (RDT&E) Division's (NRaD) Communications Department is conducting applied research toward the development of a high-data-rate (HDR), line-of sight (LOS), digital modem for ship-to-ship, ship-to-shore, and ship-to-relay communications. Development of bandwidth efficient HDR communications in a maritime radio environment is a challenging research problem due to the time-varying propagation effects within the marine layer. Marine layer propagation typically causes fading of the signal spectrum due to RF interference effects, and intersymbol interference because of multipath induced time spreading. The use of adaptive equalization to overcome distortions is difficult in this environment because of the dynamic nature of the signal propagation caused by transmitter and/or receiver motion and the maritime layer atmospheric effects. An alternative to channel equalization is the application of Coded Orthogonal Frequency Division Multiplexing (COFDM) which overcomes distortion effects without equalization through its orthogonality properties. This thesis explores the application of COFDM toward a HDR LOS maritime communications modem. The modem model is emulated in a high level programming language (MATLAB) and simulations are performed. Analysis of the simulations are conducted and evaluated as to the feasibility of a COFDM implementation in the presence of known noise and signal fading conditions.

### **HIGH-ACCURACY DISTRIBUTED SENSOR TIME-SPACE-POSITION INFORMATION SYSTEM FOR CAPTIVE-CARRY FIELD EXPERIMENTS**

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**Master of Science in Applied Physics-December 1996**

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**Second Reader: Robert C. Harney, Department of Physics**

Operational EW test and evaluation experiments require that the position of the aircraft and other moving objects on the range be known precisely as a function of time. Terminal Time-Space-Position Information (TSPI) Systems involve the range platforms interacting at close distances and therefore require precise trajectory information over a restricted volume of space. Terminal TPSI systems are used for tactics evaluation and the evaluation of simulated weapons firings (e.g., captive-carry hardware-in-the-loop missile simulators). Distributed sensor TSPI systems consist of two or more measurement sensors located some distance from each other. Each sensor makes a measurement of target angle and range. Distributed sensor systems are more complex than single-point systems involving multiple hardware installations, complex mathematical computations to extract coordinate information, synchronization of multiple measurements and calibration of a number of different stations.

## 1997 THESIS ABSTRACTS

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This paper presents a novel distributed sensor TSPI architecture that provides precise positioning information of the target relative to a fixed inertial coordinate system. The architecture efficiently integrates the information from an inertial navigation system (INS), a global positioning system (GPS) and any number of distributed RF sensors which may be located onboard a captive-carry aircraft. The significance of this work is that by knowing the target's position in a fixed inertial frame of reference (derived from the integration process) an evaluation can be made as to the effectiveness of any electronic attack or off-board decoys that might have been launched during the field test scenario. The induced INS, GPS and sensor noise and the corresponding errors due to the integration process are evaluated numerically as a function of the weapon system being used. The accuracy in the targeting information is also quantified and compared with the true expected values.

### **IN-SITU TESTING OF RADIATION EFFECTS ON VLSI CAPACITORS USING THE NPS LINEAR ACCELERATOR**

**Duane Salsbury-Lieutenant, United States Navy**

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**Master of Science in Electrical Engineering-December 1996**

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**Second Reader: Todd Weatherford, Department of Electrical and Computer Engineering**

The study of radiation effects on VLSI components is a very heavily researched topic. There are several reasons for this research, one of which is the application of VLSI components to space related vehicles. One component essential to Analog VLSI elements is the capacitor. The purpose of this paper is to better define the actual effects of radiation on the MOS VLSI capacitor. The radiation testing is conducted using the NPS electron linear accelerator. The data is taken while the capacitor is being exposed to an accumulating dose of electron radiation. The capacitance values are monitored using the parameter changes of a specially designed low pass filter circuit. The 3 dB breakpoint frequency of this filter is used to calculate the actual capacitance. The capacitance value is then related to the accumulated radiation dose in Rads. The results are very important and needed, especially if off-the-shelf components are to be utilized in the design of spacecraft systems.

### **DESIGNING FAST GOLAY ENCODER/DECODER IN XILINX XACT WITH MENTOR GRAPHICS CAD INTERFACE**

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**Master of Science in Electrical Engineering-March 1997**

**Advisor: Chin Hwa Lee, Department of Electrical and Computer Engineering**

The programmable logic array is one of the most fascinating and fast developing areas of technology. Field programmable gate arrays are becoming prevalent in design as the density of the gate arrays goes up. In this study, a fast encoding/decoding algorithm, Extended Golay Coding, is implemented in Xilinx XC4000 family programmable gate array (FPGA) architecture. The encoder/decoder is designed using the Xilinx XACT tool with the Mentor Graphics schematic capture Design Architect (DA) and QuicksimII simulation interfaces. With the static RAM bits onboard the new Xilinx FPGAs, the architecture is more powerful, and it is relatively easy to upgrade the old design based on the needs of the users. In this thesis, fast encoder/decoder is implemented with transmission word redundancy and interleaving. This is based on the data link layer description of the Milstd 181-144A. The FPGA static RAM bits are used for the encode and decode ROM of the algorithm that makes the coder faster. Modular approach and design hierarchy made design tasks easier and upgradable in this study. The timing simulations of some design modules will be presented. Due to the complexity of the circuits, it is found that the design has to be migrated to a higher density chip than XC4003 used in the simulations.

## 1997 THESIS ABSTRACTS

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### **THE DESIGN AND INSTALLATION OF A GLOBAL BROADCAST SERVICE DEMONSTRATION PROJECT AT THE NAVAL POSTGRADUATE SCHOOL**

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**B.S., Clarkson University, 1987**

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**Advisors: Paul H. Moose, Department of Electrical and Computer Engineering**

**Rex Buddenberg, Department of Systems Management**

The author presents a detailed description of the design and installation of a Global Broadcast Service (GBS) demonstration and evaluation project at the United States Naval Postgraduate School. GBS is a Department of Defense CONUS-based Direct Broadcast Satellite (DBS) evaluation project utilizing commercial, off-the-shelf components for the reception of video, Internet Protocol (IP) and Asynchronous Transfer Mode protocol (ATM) data transmission. Direct Broadcast Satellite technology offers enormous digital relay capability with data transmission speeds on the order of 30 Mbps being available on a single satellite transponder. As modern computer and communications devices now employed by each of the armed services need access to wideband data channels to effect efficient and timely communications, this capacity has generated significant interest within the DoD. The author discusses several key DBS technical areas, including video compression methods, data throughput capacity, polarization, and frequency biasing. Proper installation techniques and suggestions are presented, in addition to other useful DBS-related material. Many significant difficulties experienced during design, installation, and initialization of the NPS testbed are discussed in detail. The author presents this information to help subsequent GBS project participants decrease the time required to design, procure, and install a semi-permanent GBS receive suite.

### **DESIGN, TESTING, AND EVALUATION OF GaAs PN SEQUENCE GENERATOR CIRCUITS IMPLEMENTED IN DIRECTLY COUPLED FET LOGIC (DCFL) AND TWO PHASE DYNAMIC FET LOGIC (TDFL)**

**Michael Warren Schimpf-Lieutenant, United States Navy**

**B.S., Massachusetts Institute of Technology, 1987**

**Master of Science in Electrical Engineering-September 1997**

**Advisor: Douglas J. Fouts, Department of Electrical and Computer Engineering**

**Second Reader: Todd R. Weatherford, Department of Electrical and Computer Engineering**

Spaceborne and military communications hardware demands very high-speed circuitry even under high radiation exposure. GaAs field effect transistors have the desirable quality that they possess rapid switching rates and are inherently more resistant to total-dose radiation induced failure than their silicon CMOS counterparts. This thesis project involves the design, simulation, and submission for fabrication, testing, and evaluation of a 1-GHz, 7-bit, pseudo-noise sequence generator (PNSG) which has numerous communications applications, particularly in spread-spectrum communications. The basic design of the PNSG is provided first, then topology-specific design considerations are covered for directly coupled FET logic (DCFL) and two-phase dynamic FET logic (TDFL) implementations. Analysis and comparison of circuit performance characteristics are completed, demonstrating the significant improvements in speed, layout area, and power consumption that dynamic logic offers.

## 1997 THESIS ABSTRACTS

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### **EXPECTED PERFORMANCE OF THE GLOBAL BROADCAST SERVICE, (GBS) PHASE II, WITH EMPHASIS ON ENVIRONMENTAL LIMITATIONS TO SUPPORTABLE DATA RATES**

**Stephen D. Scotty-Lieutenant, United States Navy**

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**Master of Science in System Technology-June 1997**

**Advisors: Paul H. Moose, Department of Electrical and Computer Engineering**

**Tri T. Ha, Department of Electrical and Computer Engineering**

The U.S. military requires a high capacity, high availability broadcast capability to provide timely dissemination of standard products to users who cannot rely on terrestrial links. The Global Broadcast Service (GBS) is being developed to meet this requirement. The key limiting factor in GBS availability is environmental losses, specifically atmospheric absorption and rainfall loss. The optimum frequency band for GBS would have been between 1-10 GHz. At this frequency range, environmental losses are negligible. However, congestion in this frequency range has forced DoD to choose a much higher frequency band for GBS, 20/30 GHz (K/Ka band). At this frequency band environmental losses, specifically rain loss, will be a key limiting factor to GBS availability. This thesis analyzes GBS Phase II performance taking into account atmospheric limitations. A key problem in determining the performance of GBS lies in the accuracy of existing rain loss models. Several rain loss prediction models were considered, and based on studies conducted by the ITU-R and Stanford Telecom, the USA rain model was chosen for this analysis. This thesis has shown that, due to environmental losses, high availability can best be achieved if GBS is capable of lowering its data rate during periods of precipitation.

### **AN ADAPTIVE METHOD FOR THE ENHANCED FUSION OF LOW-LIGHT VISIBLE AND UNCOOLED THERMAL INFRARED IMAGERY**

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**Master of Science in Electrical Engineering-June 1997**

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**Second Reader: William K. Krebs, Department of Operations Research**

Night vision sensors, such as image-intensifier (II) tubes in night vision goggles and forward looking infrared sensors (FLIR) are routinely used by U.S. naval personnel for night operations. The quality of imagery from these devices however, can be extremely poor. Since these sensors exploit different regions of the electromagnetic spectrum, the information they provide is often complementary, and therefore, improvements are possible with the enhancement and subsequent fusion of this information into a single presentation. Such processing can maximize scene content by incorporating information from both images as well as increase contrast and dynamic range. This thesis introduces a new algorithm, which produces such an enhanced/fused image. It performs adaptive enhancement of both the low-light visible (II) and thermal infrared imagery (IR) inputs, followed by a data fusion for combining the two images into a composite image. The methodology for visual testing of the algorithm for comparison of fused and original II and IR imagery is also presented and a discussion of the results is included. Tests confirmed that the fusion algorithm resulted in significant improvement over either single-band image.



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## 1997 THESIS ABSTRACTS

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### **SINGLE EVENT ANALYSIS OF LOW TEMPERATURE GALLIUM ARSENIDE FIELD EFFECT TRANSISTOR TECHNOLOGY**

**Michael L. Shumberger-Lieutenant, United States Navy**

**B.S., University of Puget Sound, 1989**

**Master of Science in Electrical Engineering-March 1997**

**Advisor: Todd R. Weatherford, Department of Electrical and Computer Engineering**

**Second Reader: Douglas J. Fouts, Department of Electrical and Computer Engineering**

Previous research has indicated that up to an eight order-of-magnitude reduction in the single-event upset (SEU) rate may be possible by using a buried low temperature (LT) grown buffer layer beneath the transistors in GaAs ICs. A two-dimensional model for the complementary GaAs heterostructure rFET of the Motorola CGaAs™ fabrication process is developed and device performance and SEU susceptibility is characterized. The model was investigated to: 1) compare conventional GaAs FET technology to GaAs FETs fabricated on LT GaAs buffers and 2) perform SEU simulations in a CGaAs™ Inverter to characterize SEU susceptibility of the LT GaAs FET.

### **INTERACTION OF LASER BEAMS WITH RELATIVISTIC ELECTRONS**

**Douglas W. Small-Lieutenant-United States Navy**

**B.S., Marquette University, 1988**

**Doctor of Philosophy in Physics-March 1997**

**Advisors: William B. Colson, Department of Physics**

**Robert L. Armstead, Department of Physics**

**Karlheinz E. Woehler, Department of Physics**

**James H. Luscombe, Department of Physics**

**Ron J. Pieper, Department of Electrical and Computer Engineering**

Motivated by the desire to put a free electron laser (FEL) weapon on a ship, the FEL and the related process of Compton backscattering are studied. The theme of the majority of this work is the interaction of the Gaussian optical mode with a beam of relativistic electrons.

Classical FEL theory is reviewed in Chapter II. Simulations based on the classical theory are used in Chapter III to study a proposed 1 kW (kilowatt) infrared FEL. In Chapter IV, simulation is used to study the problem of electron beam/optical mode overlap in an ultraviolet (UV) FEL. A new concept, the FEL with a short Rayleigh length, is studied in Chapter V. The idea is tested on the UV FEL, then used to design and simulate a megawatt-class FEL for ship self-defense.

An analytical calculation of the Compton backscattering of laser light is performed in Chapter VI. A quantum electrodynamics (QED) formalism is used to find the spectrum and angular distribution of photons scattered out of a Gaussian optical mode by relativistic electrons.

### **FINAL DESIGN, INTEGRATION, AND VALIDATION OF THE PANSAT ANTENNA SYSTEM**

**Gary J. Smilowitz-Lieutenant Commander, United States Navy**

**B.E.E.E., Vanderbilt University, 1985**

**Master of Science in Electrical Engineering-March 1997**

**Advisor: Richard W. Adler, Department of Electrical and Computer Engineering**

**Second Reader: Rudolf Panholzer, Space Systems Academic Group**

In this thesis, the final design for the Petite Amateur Navy Satellite (PANSAT) antenna system is constructed, integrated, and validated. The antenna elements and matching network are field tested and compared to the Numerical Electromagnetics Code (NEC) model. The final free-space radiation pattern and its power gain distribution will be used to help track PANSAT's rotation during its orbit.

## 1997 THESIS ABSTRACTS

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### **A SIGNAL PROCESSING PERSPECTIVE OF HYPERSPECTRAL IMAGERY ANALYSIS TECHNIQUES**

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A new class of remote sensing data with great potential for the accurate identification of surface materials is termed hyperspectral imagery. Airborne or satellite imaging spectrometers record reflected solar or emissive thermal electromagnetic energy in hundreds of contiguous narrow spectral bands. The substantial dimensionality and unique character of hyperspectral imagery require techniques which differ substantially from traditional imagery analysis. One such approach is offered by a signal processing paradigm, which seeks to detect signals in the presence of noise and multiple interfering signals.

This study reviews existing hyperspectral imagery analysis techniques from a signal processing perspective and arranges them in a contextual hierarchy. It focuses on a large subset of analysis techniques based on linear transform and subspace projection theory, a well established part of signal processing. Four broad families of linear transformation-based analysis techniques are specified by the amounts of available a priori scene information. Strengths and weaknesses of each technique are developed. In general, the spectral angle mapper (SAM) and the orthogonal subspace projection (OSP) techniques gave the best results and highest signal-to-clutter ratios (SCRs). In the case of minority targets, where a small number of target pixels occurred over the entire scene, the low probability of detection (LPD) technique performed well.

### **THE USE OF COMMERCIAL LOW EARTH ORBIT SATELLITE SYSTEMS TO SUPPORT DOD COMMUNICATIONS**

**Haralambos Stelianos-Captain, Hellenic Army**

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**Master of Science in Electrical Engineering-December 1996**

**Advisors: Tri T. Ha, Department of Electrical and Computer Engineering**

**Vicente Garcia, National Security Affairs Cryptologic Chair**

Within the next five years there will be a proliferation of commercial Low Earth Orbit (LEO) satellite systems providing voice/data services to anywhere in the world. Instead of investing heavily in new satellite systems, the military services can use these forthcoming commercial satellite systems to enhance their existing satellite-based systems. An in-depth study and detailed summary is provided in this thesis for each of the following four commercial LEO satellite systems: Iridium, Teledesic, Odyssey, and Globalstar. Then, a comparison of these systems is performed from the military point of view by using criteria such as antijam protection, security, mobility, flexibility, interoperability, coverage, and capacity. It is shown that an architecture consisting of Globalstar and Odyssey has the potential to provide communications support for DoD's less critical needs which include administration, logistics, and other support functions. Finally, other military applications of these systems are given.

## 1997 THESIS ABSTRACTS

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### **APPLICATION OF CYCLOSTATIONARY SIGNAL SELECTIVITY TO THE CARRY-ON MULTI-PLATFORM GPS ASSISTED TIME DIFFERENCE OF ARRIVAL SYSTEM**

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**Electrical Engineer-March 1997**

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Traditional methods of time difference of arrival (TDOA) determination suffer significantly in environments fraught with co-channel interference and low signal to noise ratios. Cyclostationary signal processing techniques offer solutions to the shortcomings of the traditional TDOA methods. Specifically, the Spectral Coherence Alignment (SPECCOA) method of TDOA determination, developed by the Mission Research Corp. and Statistical Signal Processing Inc., performs exceptionally in very poor signal to noise ratio environments. The Applied Research Lab at the University of Texas at Austin (ARL:UT) has developed a prototype TDOA system, the Carry-on Multi-platform GPS Assisted Time Difference of Arrival System for the Naval Information Warfare Activity. It currently utilizes a traditional complex ambiguity function (CAF) to determine the TDOA(s) between multiple observers and an ARL:UT developed closed form solution for the geolocation of the emitter. The work presented here takes the first step in applying SPECCOA to the ARL:UT system. Coding both SPECCOA and the ARL:UT closed form solution in MATLAB® makes possible a quantitative comparison between the CAF and SPECCOA using ARL:UT real world test signals.

### **DESIGN, CONSTRUCTION, AND PROGRAMMING OF A MICROCONTROLLER-BASED TESTBENCH SUITABLE FOR RADIATION TESTING OF MICROELECTRONIC CIRCUITS**

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**Advisor: Douglas Fouts, Department of Electrical and Computer Engineering**

**Second Reader: Todd Weatherford, Department of Electrical and Computer Engineering**

This thesis describes the design, construction, and programming of a microcontroller-based testbench suitable for radiation testing microelectronic integrated circuits. It will be used to test circuits fabricated using the Low Temperature Gallium Arsenide (LT GaAs) fabrication process developed by the Naval Postgraduate School and the Naval Research Laboratory. The testbench will be used to test for sensitivity to Single Event Upsets (changes in logic level due to impact by high-energy ions). Due to the spurious radiation around the particle accelerator, it will be remotely operated via a serial communication port. Radiation hardened components will eventually be used throughout, although for cost-savings, non-radiation hardened components are used in the initial design described here. The test bench is built around the Intel 87C51 four-port microcontroller. As part of this research, it will be programmed to test two memory chips, one manufactured by Motorola Inc. and one by Vitesse Semiconductor Corporation. The Motorola chip requires that a special chip carrier with logic translation and output drivers be designed prior to testing.

## **1997 THESIS ABSTRACTS**

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### **ECONOMIC EVALUATION OF VOICE RECOGNITION (VR) FOR THE CLINICIANS' DESKTOP AT THE NAVAL HOSPITAL ROOSEVELT ROADS (NHRR)**

**Erik Threet-Lieutenant, United States Navy**

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**Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering**

**William R. Gates, Department of System Management**

Beyond keyboards, mice, trackballs, and other means to communicate with computers, the spoken word remains the ultimate, if not elusive, user interface. Recent developments in hardware and software have brought the ability to control a computer with the spoken word closer to reality. This thesis investigates the current status of VR technology, its use in support of Joint Vision 2010, its use in the Healthcare environment and provides an analysis of the VR Pilot Project at NHRRs. The objective of the analysis is to determine the viability and economical benefits of using a commercial-off-the-shelf (COTS) VR application as a clinicians input device for transcribing clinical encounter (SOAP) notes. The VR application used in this study was the DragonDictate Classic Edition with the DragonMed add on module for healthcare professionals.

The results show that VR technology is a viable tool that can add numerous economical benefits, such as, a decrease in the time clinicians spend transcribing SOAP notes, eliminates the need to hire medical transcriptionists and reduces Graphical User Interface (GUI) overload for Window's based Navy Medical Standard systems. In addition, findings indicate that the use of computer technology, during clinical encounters, has no significant effect on patient/clinician relationships.

### **THE ASTRODYNAMIC PROBLEMS OF DIGITAL TDMA SIGNAL DETECTION**

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**B.S., Oregon Institute of Technology, 1986**

**Master of Science in Electrical Engineering-December 1996**

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**Vicente C. Garcia, National Security Affairs Cryptologic Chair**

Worldwide consumer demand for personal digital communications products and services has been explosive. Many U.S. and foreign corporations have plunged into the market with high quality electronic components and communications services far in advance of those currently used by today's operating forces. Several satellite systems are being readied for launch that will enable private citizens, commercial enterprises and other entities to communicate from anywhere to anywhere in the world. Cellular communications networks offer developing countries that have little or no communications infrastructure significant cost savings when compared to traditional wireline setups; it satisfies the most basic communications requirements without a hefty investment in copper cable. Modern systems allow this communication to occur in secure voice or data, operating in the networked, broadcast, or point to point modes. For military applications, the detection of advanced digital TDMA signals from space in a hostile environment involves a number of problems. Several of these are addressed.

### **ESTABLISHING A SIGNALS ANALYSIS WORKSTATION (U)**

**Thomas G. Trotter-Lieutenant, United States Navy**

**B.S.E.E., United States Naval Academy, 1988**

**Master of Science in Electrical Engineering-December 1996**

**Advisors: Vicente C. Garcia, National Security Affairs Cryptologic Chair**

**Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering**

In an era of the information age, the advent of digital hardware technology has enabled digital signal processing techniques to flourish and transform communications from analog to digital formats. Unlike analog communication systems, digital communication systems interface inherently easily with computer hardware and software processes. Such a relationship

## 1997 THESIS ABSTRACTS

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has propelled the users forward with endless transmission possibilities. Former methods dedicated to the venerable analog systems are antiquated and utterly useless against this new class of digital transmissions. This same new technological power available to the intended communication system users is also available to third parties engaged in exploiting these signals of interest. This thesis first presents the processes of converting an analog signal to digital format and the major time division multiplexing standards employed throughout the world. It then introduces specific software tool kits that demodulate the intercepted signals and conduct bitstream analysis of the signals. Finally signals of interest are presented with step-by-step analysis on each specific signal.

### **INSTRUMENTING THE NAVAL POSTGRADUATE SCHOOL GLOBAL BROADCAST SERVICE TESTBED FACILITY**

**John A. Watkins-Lieutenant, United States Navy**

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**Master of Science in Information Technology Management-June 1997**

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**Carl R. Jones, Department of Systems Management**

The work reported in this thesis used readily available components to implement a data acquisition system for a Global Broadcast Service Testbed data collection facility. Use of hardware with controlling software is necessary to collect signal power content of satellite signals at a given distance from the transmitting source. Precise measurement and calibration of a satellite receive signal is accomplished by use of an Hewlett-Packard 8568B spectrum analyzer. A personal computer is used to collect and store retrieved data. These components are brought together using LabVIEW instrumentation software. This system provides an efficient means to collect signal data which can be used to verify satellite link performance estimates. Calculations are performed using Matlab statistical analysis software. This thesis contains calculated and measured values of total average carrier power and background noise levels for the three satellite receive systems that comprise the Naval Postgraduate School Global Broadcast Service Testbed facility.

### **ELECTROMAGNETIC IMAGING OF AXISYMMETRIC SCATTERERS**

**Daniel J. Wawrzyniak-Major, United States Marine Corps**

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**Master of Science in Electrical Engineering-June 1997**

**Advisor: Michael A. Morgan, Department of Electrical and Computer Engineering**

**Second Reader: David C. Jenn, Department of Electrical and Computer Engineering**

Radar cross-section is a key element of low-observability. In order to reduce the cross-section of a particular platform, it may be necessary to determine the induced source distribution on the platform which produces the scattered electromagnetic radiation. Determining the distribution may be possible using a probe to measure fields on or near the outer surface of the object. However, the act of measuring may indeed influence the currents being measured. An alternate method is to back-propagate measurements made at distances beyond the realm of strong influence on the parameters of interest to construct visualizations of the local on-surface radiation contributions. This has been demonstrated for the case of cylindrical geometry. The theory is extended in this thesis to axisymmetric bodies for the special case of rotationally symmetric fields.

## 1997 THESIS ABSTRACTS

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### **ANALYSIS OF THE USE OF THE MACH-ZENDER COUPLER IN DEMODULATING MULTIPLEXED FIBER OPTIC SIGNALS**

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**Master of Science in Electrical Engineering-September 1997**

**Advisor: Tri Ha, Department of Electrical and Computer Engineering**

**Second Reader: John P. Powers, Department of Electrical and Computer Engineering**

Fiber optic communications are the future of U.S. Navy shipboard communications. They present tremendous bandwidths with no susceptibility to electro-magnetic interference (EMI) and outstanding signal-to-noise ratios. Current technology uses wavelength division multiplexing (WDM) to allow multiple users on a single fiber simultaneously. The optical filters necessary to demodulate the WDM signal can be expensive. A less costly alternative could be achieved if Hadamard-Walsh Code Shift Keyed (CSK) encoded signals were used. An optical receiver was proposed, using the Mach-Zender coupler, capable of demodulating a Hadamard-Walsh CSK encoded signal. Building on previous work studying the characteristics of the Mach-Zender coupler, a relationship between the probability of bit error and signal-to-noise ratio (SNR) was developed for a single user and a DPSK optical signal. This relationship was then used to develop an understanding of the bit-error rate to SNR relationship for a multiple-user CSK optical signal. Using the theoretical performance as a guide, a MATLAB model was then constructed to investigate the sensitivity of the receiver to non-ideal components.

### **AUTOMATIC EXTRACTION OF THREAT SIMULATOR CRITICAL PARAMETERS, VERSION 2.0 (U)**

**Martin J. Welch-Civilian**

**Master of Science in Electrical Engineering-June 1997**

**Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering**

**Second Reader: David S. Woodson, III, Naval Research Laboratory**

Anti-ship cruise missile (ASCM) threat simulator validation is a critical component of both the test and evaluation of shipborne electronic warfare (EW) systems and EW system operator training. The Navy unique ASCM simulator validation working group (SVWG) is responsible for evaluating the measured performance of these simulators with respect to their intended use. An important part of validation is comparing measured threat simulator radar parameters (or derived parameters based on the measured parameters) to the known or estimated parameters compiled in the Electronic Warfare Integrated Reprogramming (EWIR) database. The Naval Research Laboratory (NRL) conducts a battery of characterization tests on the various ASCM simulators using the NRL Central Target Simulator (CTS) to measure threat simulator seeker performance characteristics. The data collected during the characterization tests are used to compute threat simulator parameters that the SVWG can use to assess the simulator performance with respect to the EWIR database values. The AETSCP version 2.0 program automatically computes 44 threat simulator parameters, 35 of which are considered critical. This thesis documents the evaluation of the Automatic Extraction of Threat Simulator Critical Parameters (AETSCP) software version 1.2 and the resulting modifications, enhancements and additional capabilities incorporated into the AETSCP version 2.0.

### **TACTICAL UNMANNED AERIAL VEHICLES USED AS STAND-IN JAMMING PLATFORMS (U)**

**Anhtuan N. Wilson-Lieutenant, United States Navy**

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**Master of Science in Systems Engineering-September 1997**

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**Second Reader: Donald v. Z. Wadsworth, Department of Electrical and Computer Engineering**

Electronic Attack plays an important role in support of Information Warfare. Electronic attacks on enemy radar systems limits their use of the electromagnetic spectrum for detection of in-coming aircraft, causing them to be incapable of defend-

## 1997 THESIS ABSTRACTS

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ing their airspace during an attack. By taking advantage of modern technology and supporting military actions, the use of tactical Unmanned Aerial Vehicles (UAVs) as stand-in jammers extend the military's ability to suppress enemy radar systems. UAVs can be used to fly riskier missions than current electronic attack aircraft such as the EA6B because the loss of the vehicle has no potential for loss of human life. UAVs are feasible platforms for conducting stand-in jamming. By comparing various UAVs and decomposing a stand-in jamming mission into its operational and functional parts, the effectiveness of tactical UAVs to perform this mission is demonstrated. Matlab is used in conjunction with IMOM version 3.2 to compute the effectiveness of stand-in jamming against various radar systems.

### **LOW ALTITUDE OPTICAL SIGNAL PROPAGATION OVER THE OCEAN**

**Lean-Weng Yeoh, Ministry of Defence, Singapore**

**E.E., Naval Postgraduate School, 1990**

**Doctor of Philosophy in Electrical Engineering-March 1997**

**Dissertation Advisor: Hung-Mou Lee, Department of Electrical and Computer Engineering**

The effects of ocean surface waves on optical signal fluctuations and optical refraction are evaluated. The effects on signal fluctuations were inferred from the ocean surface wave spectral density and temperature fluctuation spectral density. The effects of ocean waves on optical refraction are manifested in the near-surface gradient of the temperature profile. A modified temperature profile incorporating a statistical mixing length scale is proposed. The research points to the importance of certain parameters that should be considered when optical signals skim the ocean surface.

### **ELECTROMAGNETIC SCATTERING OF AN ANISOTROPICALLY COATED TUBULAR CYLINDER**

**Chen-Kuo Yu-Captain, Republic of China Navy**

**M.S.S.E., Naval Postgraduate School, 1990**

**Doctor of Philosophy in Electrical Engineering-March 1997**

**Advisor: Hung-Mou Lee, Department of Electrical and Computer Engineering**

The sum-difference surface current formulation is introduced to treat electromagnetic boundary value problems when anisotropic impedances are specified on both sides of a surface. It can also be applied to impedance coated bodies. This formulation preserves the duality nature of Maxwell equations and carries it over into the algebraic form of the integrodifferential operators in the equations for surface currents. Since a  $90^\circ$  rotation is equivalent to undergoing a duality transform for an incident plane wave, this particular symmetry in the algebraic form of the operators leads to sufficient conditions under which the on-axis backscattering of an anisotropic impedance coated scatterer having a  $90^\circ$  rotational symmetry is eliminated. The sum-difference formulation is utilized for solving the problem of electromagnetic scattering from an anisotropically impedance coated tubular cylinder of finite length. The solution has been coded in FORTRAN and tested. Some interesting results are presented and discussed.

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